CHAPTER 6: ISSUES AND OPPORTUNITIES TO MANAGING THE RANGE RESOURCE

INTRODUCTION

The projections discussed in Chapters 4 and 5 identified future shifts in the forage production. Forage production on public lands and from irrigated pasture was projected to increase only slightly whereas the total demand for livestock forage was expected to rise. The relative declines in these sources of forage suggest that the management of alternative sources of forage, such as private lands, will intensify. Not only will this intensification involve livestock grazing, but also the need to diversify ranch/farm operations to stabilize income over the long term. Increasing demands for wildlife, recreation, and water production are also suggested (Flather and Hoekstra in press, Guldin in press). A future in which resource use intensifies, but management does not, poses the possibility that our Nation's ecosystems will not likely improve in condition or productivity. The management issues associated with the range resource are now broader than domestic livestock grazing. One important aspect of this national assessment is to review issues and opportunities that exist to potentially reduce these impacts and costs.

Management issues and opportunities are grouped into four categories: the *management of range vegetation; management of grazers and browsers*, both wild and domestic; *social issues*; and *planning*. Reports from National Forest System (NFS) range, wildlife, and fish managers, Bureau of Land Management (BLM) wildlife and fish managers, and state wildlife and fish managers were reviewed for perceptions of current management issues, opportunities that exist to address these issues, and obstacles to resolving these issues. In addition, published reports by special interest groups, professional organizations, producer groups, and universities were reviewed.

RANGE VEGETATION MANAGEMENT

Vegetation management issues revolved around providing the type of vegetation on public and private lands necessary for the production of a mix of resource outputs including forage for domestic and wild herbivores, water quality and quantity, air quality, open space, endangered plants and animals, genetic material, recreational use, plant diversity, community stability, scenic quality, and minerals (Cordell in press, Flather and Hoekstra in press, Guldin in press, USDA Forest Service 1988b, USDA Forest Service RPA Staff in press). Management issues of particular concern included the seasonal and spatial availability of forages for both wild and domestic herbivores, healthy riparian vegetation, and the control of undesirable plants.

Availability of Forage for Wild and Domestic Herbivores

Issues

An adequate supply of year-round forage for wild and domestic herbivores, the exceeded life-time of existing range improvement practices, natural successional changes reducing habitat or forage availability, and human activities reducing habitat and forage availability were seen as limiting factors in the management of wild and domestic herbivores (Flather and Hoekstra in press, USDA Forest Service 1988b, USDA Soil Conservation Service 1987c, U.S. General Accounting Office 1988). The projected declines in the regional availability of public forage and irrigated pastures (Chapter 4) will intensify the increasing demands for alternative sources of forage.

Plant production is greatest during periods of adequate moisture and optimal temperature. Outside of their optimal growth periods, grasses, forbs, and shrubs may grow little, if at all. During these periods, accessibility to alternative sources of forage is critical for wild and domestic grazers. Poor vegetative conditions in crucial winter range is a management issue for big game (Flather and Hoekstra in press). Inadequate forage production in cool-season pastures during the summer months is a concern in the Northern region (USDA Forest Service 1988b, USDA Soil Conservation Service 1987b). Summer range for pronghorn in the Rocky Mountain region is poor because of a lack of forbs that remain green during July and August (Flather and Hoekstra in press). Alternative nutritional sources of forage during the winter in the Southern region are needed for domestic grazers.

The expired lifetime utility of many range improvement practices and the need to broaden the types of practices implemented were concerns for most range managers (USDA Forest Service 1988b). Range plant control treatments are designed to temporarily shift plant succession (Young 1983). Many of these improvement practices were implemented several years ago and succession has resulted in the need to again treat these sites to maintain the present grazing strategy. On public lands, the lack of range funds and declining budgets have restricted the implementation of improvement practices (fig. 52). In 1985, the Forest Service had 561 range conservationists and technicians overseeing 9,000 grazing allotments within 103 million acres. Thus on average, each person oversees 16 grazing allotments covering 184,000 acres (U.S. General Accounting Office 1988). Declining range improvement funds has restricted improvement practices on BLM-administered lands also. A current vegetation analysis is needed before

developing range management objectives for NFS lands. Range managers were concerned that lack of funds and personnel would restrict the development of ecological guidelines for conducting these vegetation analyses (USDA Forest Service 1988b). On private lands, the economic incentive to implement range improvement practices has weakened (Chapter 3). This economically-driven delay in range improvement on public and private lands is intensified because the original practices such as chemical spraying or fire are no longer acceptable, and suitable economic alternatives may not exist.

The need to broaden the types of practices implemented on pasture/rangeland is the result of traditional attitudes limiting improvement practices, in addition to environmental restrictions on previously used treatments, such as herbicides. Traditional attitudes concerning range management limit the approaches that can be taken on forest and rangelands. The spacing of tree plantings at similar densities in southern timber plantations can inhibit forage production (evenly spaced) or enhance forage production (unevenly spaced across the field). Often, fertilization and liming were the only management practices considered in the Northern region (USDA Forest Service 1988b). The benefits of converting to cool-season grasses and of delaying livestock grazing were often not obvious to land managers. In a survey by the National Association of Conservation Districts, ranchers and farmers believed that the education of land operators was essential to achieve the application of proven range management practices (National Association of Conservation Districts 1979).

Succession affects continual changes in the vegetation structure on forest and rangelands (fig. 22). Abandonment of cropland and pastures, particularly in eastern United States, has resulted in declining acreages of open nonforested habitat, as the plant community moves toward the potential natural community. This displaces some wildlife species, represents a forage loss for wild and domestic herbivores, and also results in a loss of scenic vistas (Flather and Hoekstra in press). In some ecosystems, past use has been so intensive as to shift the ecosystem response to management (Chapter 2). Conversion to return the original vegetation type is an expensive process.

The USDA Soil Conservation Service (1987c) reported that nationally nearly 117 million acres of rangeland require intensive treatment such as brush management, range seeding, or erosion control. Brush treatment was recommended for sites where these invading woody plants were not part of the climax plant community or where these plants have expanded to densities much greater than the natural community. Not only does the encroachment of shrubs reduce forage, but water runoff may be higher, accelerating soil erosion (USDA Soil Conservation Service 1987c).

Opportunities

Management opportunities for range vegetation management exist in previously developed but not yet implemented technology, and in developing technology. The seasonal availability of forage can be improved by interseeding of a mixture of species within a pasture, converting part of the grazingland to other forage species, or adjusting the mix of animal species. Seeding warm-season grasses in cool-season pastures extends the period of available forage in the Northern region and in the plains area of the Northern Rocky Mountain region. On-going research at federal and state agricultural experiment stations is accelerating the interest in and use of warm-season grasses (USDA Soil Conservation Service 1987b). Techniques have been developed to process native grass seeds so that conventional grass drills can be used, and the availability of drills capable of seeding native seed is also increasing (USDA Soil Conservation Service 1987b).

Subterranean clover is a cool-season forage legume that may potentially improve winter nutrition for herbivores, and indirectly small game, on forested rangelands in the South (Johnson et al. 1986, Ribbeck et al. 1987). This species would grow most during the winter when other forage is of poor nutritional quality. This clover is also a major spring forage on the western coast of the Pacific Coast region. The only disadvantage is that it requires intensive grazing and management to be productive. Opportunities to interseed arid rangelands with adapted forbs were seen as possible methods to extend summer range use for pronghorns. On big game winter range, a reduction of domestic grazing could provide additional forage.

Within a mosaic of land ownerships, changing land uses place increasing importance on the vegetation management on lands available for grazing. Development around public lands such as ski developments or second homes, or the encroachment of urban lands into the rural areas creates barriers to migratory wildlife routes and limits access for livestock grazing. Coordinated management opportunities exist to mitigate problems associated with changing land uses or intermixes of land uses. Opportunities to exchange lands to block up crucial winter ranges in public ownership were seen as possibilities to address the seasonal shortage of forage for big game. Opportunities to mitigate the habitat loss of wildlife species also includes the outright purchase of lands by federal, state, or private groups (Flather and Hoekstra in press).

Research Needs

The lack of ecological knowledge in vegetation management and the need for technology transfer from researchers to managers were seen as issues in vegetation management research. A comprehensive understanding of the regulatory mechanisms of plant growth and how it responds to environmental extremes are objectives for further research (Society for Range Management 1989). Existing models used in resource management to forecast future plant communities and resource outputs have not been tested in different ecosystems or under different successional stages, and

the underlying ecological assumptions in these models need further examination (Sweeney and Wolters 1986). Additional study is needed to determine the impact of grazing systems on vegetation productivity (USDA Soil Conservation Service 1987b). Sustainable management systems to integrate land uses are needed to manage vegetation and other components of the ecosystem (see Planning section of this chapter).

Healthy Riparian Vegetation

Issues

Many western public resource managers believe that conflict arising over the management of riparian zones is, except for timber management, the most potentially explosive issue of today (Prouty 1987). The 1986 Audubon Wildlife Report identified damage to riparian zones by cattle grazing on public lands as the most serious current conflict between wildlife and livestock (Barton and Fosburgh 1986). Over 90,000 miles of streams and rivers providing nearly 3 million acres of riparian habitat are administered by the NFS and BLM (Prouty 1987). Riparian areas are attractive to recreationists for many reasons including presence of water, easy access, fishing opportunities, and esthetically appealing landscape (Johnson and Carothers 1982, Melton et al. 1984, Skovlin 1984). The stability and integrity of streambanks, and adequate shade and overhanging cover are important in maintaining healthy fish populations (Cummins 1974, Moring et al. 1985).

Riparian zones contain higher density and diversity of plant and animal species than adjacent uplands (Odum 1979). Livestock and wildlife use riparian areas disproportionately more often than upland habitats (Kauffman and Krueger 1984, Marlow and Pogacnik 1986). In Oregon, a riparian zone comprising less than 2% of the total land area produced 21% of the available forage and accounted for 81% of the total herbaceous vegetation removed by livestock (Roath and Krueger 1982). Of the 166 bird species nesting in southwestern United States, 127 (77%) were dependent on water-related habitat (Johnson et al. 1977). Forty percent of the vertebrate wildlife species in Colorado are associated with riparian areas that occupy 3% of the land area (Melton et al. 1984). Riparian zones also serve as migration corridors for wildlife, especially big game traveling between summer and winter ranges (Melton et al. 1984, Thomas et al. 1979). With all of these demands, riparian ecosystems are the most critical area for multiple-use planning (Platts 1979).

Opportunities

Proper vegetation management of riparian zones can produce a variety of resource outputs, including fisheries, wildlife, recreation, livestock, and water quantity and quality. Wildlife that utilize riparian areas include big game such as deer and elk, small game, nongame, and furbearers. Riparian area management presents the biggest challenge and opportunity for multiresource planning and cooperation. Western rangeland streams are in their present condition because 100 years of small, annual degrading effects were cumulative over time. Land managers must administer grazing strategies with finesse to meet today's needs while attempting to correct the mistakes of the past (Platts and Raleigh 1984).

Based on early research on riparian zones, many allotments on NFS lands receive less overall livestock use and have been changed from season-long grazing to other grazing systems. Rest-rotation grazing has been effective in rehabilitating riparian areas that are nonwoody or have established woody stands (Platts and Nelson 1985a). In critical fish habitat, grazing has been eliminated by fencing some stream sections to protect spawning habitat of anadromous fish. The special management pasture offers an expensive, but flexible management practice to continue grazing under more focused management (Platts and Nelson 1985b). Different livestock species graze riparian areas in different ways. Sheep, which graze riparian areas without extensive damage, are no longer present on many allotments (Platts and Raleigh 1984).

Fishery biologists are attempting to improve degraded stream sections through instream structures designed to catch sediment and through planting willows and other shrubs to stabilize streambanks (Malespin 1985, McCluskey et al. 1983, Storch 1979). Channel structures that deposit sediment enhance riparian development by providing more favorable moisture and nutrient regimes and a reduction in flow velocity (DeBano and Heede 1987). Willow planting provides habitat for many wildlife species in a short amount of time at a low cost (McCluskey et al. 1983).

Research Needs

Much has been learned in the past 20 years about the structure and function of riparian zones, but this complex ecosystem is still not fully understood. Recent and present research is concentrating on entire riparian ecosystems and watersheds (Platts 1986). Grazing strategies are being matched to the physical conditions of the grazing area (Platts and Raleigh 1984). Researchers are focusing on how riparian areas function, and studies are underway on how to get degraded streams to function properly again. The BLM in Oregon is learning how to manage mud or sediment by examining the basic stream processes and maintaining vegetative cover during peak runoff (Elmore 1988, McKinney 1988). Nutrient cycling within and through riparian areas is being studied (Warwick and Hill 1988). Changes in the microbial aspects of riparian zones may provide an early warning to unwanted successional change (Hussey et al. 1985). Scientists are also looking at the impacts of natural disturbances such as flood events and how the stream changes with these disturbances (Platts et al. 1985). Inventory techniques are being modified and refined to better judge the condition of riparian areas (Platts et al.

1987). Platts (1986) stated that research leading to successful rehabilitation of riparian areas is in its infancy and should receive the highest priority in the future.

Little information is available on the riparian habitat requirements of threatened and endangered species or invertebrates (Patton 1977, Skovlin 1984). Few studies identify how present cattle grazing strategies will restore riparian habitats (Platts and Raleigh 1984). Range managers need more information on the costs and benefits associated with different livestock management strategies. The impacts of multispecies grazing in riparian areas needs to be explored both biologically and economically. Long-term hydrologic impacts of livestock grazing need to be addressed (Blackburn 1984).

Knowledge gaps exist between fishery and wildlife biologists, and range managers (Skovlin 1984). Range, wildlife, and fishery scientists base management decisions on functional sets of criteria, such as meat production, wildlife population size, or quantity and kinds of fish (Platts and Raleigh 1984). Platts and Raleigh (1984) did not find a single published interdisciplinary grazing study in their literature review. They stated that a compelling need exists for studies that identify common goals and incorporate the concerns of all users, including ranchers, fishermen, hunters, ecologists, and recreationists.

Undesirable Plants

Issues

The spread of undesirable plants is a particular concern among resource managers (Flather and Hoekstra in press, USDA Forest Service 1988b). An undesirable plant is one that is unacceptable in light of planned land use or that is unwholesome to rangelands or range animals (Vallentine 1980).[19] These plants can be exotics that spread into the native community or native species whose dominance is undesirable. Acceptance of a plant species depends on what plant species, and how, when, where, and for what is it desirable (Vallentine 1980). Plants undesirable for one grazing animal may be valuable for other herbivores, as habitat for wildlife, or valuable to other industries such as beekeeping. For example, tall larkspur is poisonous to cattle, but is palatable, nutritious forage for deer and sheep (Vallentine 1980). The introduction and persistence of nonnative plants and animals is jeopardizing the habitat of native plants and animals including some threatened and endangered species (Chapter 2).

Species and rates of infestation differ across the United States. Diffuse and spotted knapweeds reduce forage production, decrease range carrying capacity, have high fibre content, and form solid stands with their competitive advantage of allelopathy (Maddox 1982). These two species have infested over 3.5 million acres in Oregon, Washington, Idaho, and Montana. Maddox (1979) estimated that the economic loss to cattle operations in 750,000 acres of knapweed-infested range is $600,000 annually. Grazing capacity on elk-bighorn-deer winter range has been reduced 35% to 80% from knapweed invasion in western Montana (Mass 1985). Leafy spurge can lower range carrying capacity by 50% to 75% (Maddox 1979). This loss is the result of decreased forage production from leafy spurge competition, and decreased forage availability because cattle will not graze areas heavily infested with spurge (Lym and Kirby 1987). The current infestation level is estimated at 2.5 million acres in North America (Lacey et al. 1985). Annually, $6 million is spent for spurge control and over $7 million in forage and beef production is lost from decreased forage production on spurge-infested rangelands in North Dakota (Lacey et al. 1985). Infestations of yellow starthistle have been reported in 23 of the 48 conterminous states; over 7.4 million acres are infested in California alone (Maddox et al. 1985). Although this plant has a negative impact on grazingland, grain and seed crops, and is toxic to horses, yellow starthistle is a valuable honey plant for the maintenance of bee colonies in California (Maddox et al. 1985).

Introduction and spread of exotic species has been facilitated by impurity in crop seed, adhesion to animals, soil surrounding roots of nursery stock, and the deliberate introductions of plants as forage, fiber, medicinal, ornamental, erosion control, and timber stock (Baker 1986). The spread of native species can be associated with natural succession, climatic fluctuations favoring these species, and local denudation such as road right-of-ways, stock trails, off-road vehicle use, or heavy grazing by livestock. Within a geographic area, native and exotic plants can spread along transportation corridors (railroads, highways, stock or recreation trails), and can spread by cultural practices such as cropping. The activity that most ensures a successful plant invasion is disturbance caused by human activities (Baker 1986, Mass 1985). Because the spread of undesirable species is oblivious of ownership, the problem is a multi-agency one. Lack of funding, research, technology transfer, awareness, and integrated control programs are allowing a significant increase in undesirable plant species.

The reliance of past management on chemical control has resulted in a related management concern, the loss of pesticides. Environmental legislation has increasingly focused on the dispersal of toxic substances in the environment (table 34). Previously used chemicals are being withdrawn from public and private use because of environmental concerns. This restriction places a greater importance on the development and implementation of environmentally safe control methods.

The implementation of any control method requires the consideration of costs and benefits. Fire has been the least expensive method for controlling undesirable vegetation (Stoddart et al. 1975). Poor economic conditions within the ranch/farm sector have resulted in a sharp drop in pesticide production in recent years. Surveys in North Dakota indicate that about 50% of the total combined acreage including cropland, alfalfa, hay, rangeland, and summer fallow was not treated with any pesticide in 1984 (Agrichemical Age 1986).

[19] *Federal and state laws define certain plants as noxious weeds because they are especially undesirable, troublesome, and difficult to control.*

Table 34.—Pollution control statutes in the United States.

Year passed	Statute
1970	Resource Recovery Act (amendments to the Solid Waste Disposal Act)
1972	Water Pollution Control Act Amendments
1972	Federal Environmental Pesticide Control Act (Amendments to the Federal Insecticide, Fungicide and Rodenticide Act)
1974	Safe Drinking Water Act (Amendments to the Public Health Service Act)
1976	Resource Conservation and Recovery Act (Amendments to the Resource Recovery Act focusing on hazardous wastes)
1976	Toxic Substances Control Act
1977	Clean Water Act (Amendments to the Water Pollution Control Act)
1978	Federal Insecticide, Fungicide and Rodenticide Act Amendments
1980	Comprehensive Environmental Response, Compensation, and Liability Act (commonly referred to as the Superfund)

Opportunities

The intensified public awareness of herbicide use on rangeland, coupled with increasingly sophisticated application techniques and increased knowledge of herbicide chemistry, has provided the incentive for research on the fate of herbicides in the ecosystem and for alternative control methods such as biological control. Present research on chemical control of undesirable plants has focused on short-lived chemicals that are highly toxic when first applied, are used in smaller quantities per unit area, and break down rapidly (Conservation Foundation 1984).

Increased interest in biological control agents is the result of several factors including the marginal economics of rangeland, the increased cost of petroleum-derived chemicals, the development of resistance in some weeds to herbicides, the inaccessibility of rangeland to herbicide application, and the restrictions on herbicide use along waterways and on public land (Nowierski 1984). Worldwide, 57 attempts to partially or completely control plants biologically have been successful and one of the startling successes was the control of St. Johnswort in California (Dahlsten 1986). Agents examined for use in biological control include insects, pathogens, and grazing animals (table 35). Biological control agents offer a number of management opportunities for rangelands: (1) the application on economically marginal land where expense or difficult terrain excludes the use of herbicides or cultural management, (2) permanency where the established control agents reappear annually to impact the undesired plant, (3) environmental safety with no toxic residues, (4) specificity where only the undesired species is attacked, (5) cost-effectiveness, and (6) the potential integration of biological control with chemical and cultural management strategies (Nowierski 1984). Unlike chemical or mechanical efforts that attack the plant for short-term success, biological control methods take longer to get established, the populations must build up, and the kill extends over a longer period of time as the host and control agent equilibrate. Presently many biological agents are under study, but only a few have been successfully released. Animals, such as sheep and goats, will graze plants such as leafy spurge (Fay and McElligott 1987, Landgraf et al. 1984) and can be an economically efficient method for control (Lacey et al. 1984). Proper management is needed to avoid any toxicity response to leafy spurge by sheep.

Opportunities exist to increase the public and private manager's awareness of undesirable plants through a coordinated state effort. Multiresource funding on public lands would give the range manager the funding and support to inventory, control, and monitor undesirable plants. Increasing the awareness of undesirable plants becomes important as interest in xeriscaping (landscaping with drought-hardy plants) offers another method for plant dispersal across the western United States.

Research Needs

The ecology of undesirable plant species is little known. The physiology and ecology of undesirable plants is an important step in developing environmentally sound control methods (Society for Range Management 1989). The mathematical modeling of invasion by colonizing plants has not been extensively developed but offers much promise in understanding the biology of these species (Bazzaz 1986). The ease of establishment and spread of knapweeds, the role of range condition in determining invasion rates of leafy spurge, and the unknown role of livestock grazing in the control of several undesirable plants were knowledge gaps identified for the western United States (Leininger 1988).

Although methods of chemical control may be available for a variety of undesirable plants, biological treatment is more likely only under study at present (table 35). Biological control appears to offer numerous advantages to control pests on rangelands, but several disadvantages exist. Biological agents are necessarily subjected to an exhaustive series of tests to guarantee their safety. Although geographically separate, leafy spurge, Canada thistle, and Tansy ragwort have plant relatives that are threatened or endangered plant species (table 35, Appendix C). Biological control methods must be

Table 35.—Some plant species of special concern on pasture and rangelands and their control treatments.

Species	Common Name	Treatment		Biological treatment			
		Chemical[1]	Mechanical	Insects	Pathogens	Grazing[2]	Plants[3]
Introduced							
Bromus tectorum	Cheatgrass	Yes	Yes			C	
Cardaria draba	Hoary Cress	Yes		Study[4]	Study		
Carduus acanthoides	Plumeless thistle	Yes		Study	Study		
C. nutans	Musk thistle	Yes	Yes	Study	Study		Yes
C. pycnocephalus	Italian thistle				Study		
C. tenuiflorus	Slenderflower thistle				Study		
Centaurea calcitrapa	Purple starthistle	Yes					
C. diffusa	Diffuse knapweed	Yes	Yes	Study	Study	S	
C. maculosa	Spotted knapweed	Yes	Yes	Study	Study	S,C	
C. repens	Russian knapweed	Yes	No	Study	Study	S	
C. solstitialis	Yellow starthistle	Yes		Study			
Conium maculatum	Poison hemlock	Yes					
Cytisus scoparius	Scotch broom			Study			
C. monspessulanus	French broom			Study			
Halogeton glomeratus	Halogeton	Yes		Study		S,G	
Hypericum perforatum	St. Johnswort	Yes	Yes	Yes		S	
Isatis tinctoria	Dyers woad	Yes		Study			
Lepidium latifolium	Perenial peppergrass	Yes	Yes				
Linaria dalmatica	Dalmation toadflax	Yes		Study			
Salsola paulsenii	Barbwire Russian thistle						
S. iberica	Russian thistle			Study			
Senecio jacobaea	Tansy ragwort	Yes		Yes			
Sonchus arvensis	Perennial sowthistle						
Tamarix pentandra	Saltcedar	Yes	Study				
Ulex europaeus	Gorse			Study			
Euphorbia esula	Leafy spurge	Yes	Yes	Study	Study	G, S	Yes
Cirsium arvense	Canada thistle	Yes		Study	Study	Study	Yes
Native							
Delphinium spp.	Tall larkspur	Yes				D, S	
Gutierrezia sarothrae	Snakeweed	Yes		Study	Study		
Larrea tridentata	Creosotebush	Yes	Yes	Study			
Opuntia spp.	Prickly pear cactus	Yes	Yes	Yes			
Prosopis juliflora	Mesquite	Yes	Yes	Study	Study	C,G after burn	

[1]Chemical treatment with yes indicates that there are chemicals on the market that have been used to treat this species. Species may require one or more chemical, mechanical, or biological treatments.

[2]G = Goats, S = Sheep, D = Deer, C = Cattle.

[3]Other plants can out compete this species.

[4]Research under way.

Source: After Leininger (1988); U.S. Department of Agriculture, Agricultural Research Service (1984); USDA Forest Service, Intermountain Region (1986); Vallentine (1980).

specific enough to attack only one spurge in a genus with over 100 species. These conflicts of interest intensify the research required to develop a host-specific biological agent.

Current research efforts in the use of livestock for plant control appears to be small. Brock (1988) stressed that very little is known about the impact of short-term rotational-intensive grazing programs on less desirable forage. The combination of technology in weed, range, and animal sciences in a well-defined long-term research program is needed to assess the role of livestock grazing in integrated pest management programs for range (Brock 1988).

Early work on chemical control focused on the development of long-lasting compounds which would provide long-term protection and require fewer applications (Conservation Foundation 1984), however this research did not focus on the ultimate fate of herbicides in the environment (Scifres 1977). The most important research priority identified by members of the Weed Science Society of America was the need to develop new methods for controlling the movement of herbicides into ground water, surface water, and air (McWhorter and Barrentine 1988). Within this research area, specific research topics included the development of new application techniques that minimize or eliminate herbicides and their residues in air and water, and techniques that regulate the movement of herbicides through the soil profile to avoid contamination of groundwater.

MANAGEMENT OF GRAZERS AND BROWSERS

Management issues related to wild and domestic herbivores focused on the number and kind of animals, seasonal distribution of these animals, availability of

suitable grazers and browsers, and the management of large herbivores on public lands. Although the management of livestock on private and public lands has a long history, the management of wild browsers and grazers is a relatively recent phenomena (Flather and Hoekstra in press). Questions still remain as to the specific objectives of wildlife and fish management. Should wildlife and fish be maintained on islands of habitat or as part of the total landscape (Berryman 1983)? Managing wild grazers and browsers to be part of the landscape requires integrating the forage and browse needs of these animals within a multiple species grazing program on range and forest land.

Public land managers' concerns addressed the management of land, whereas state agencies were concerned with the conversion of forest or rangeland to uses not compatible with wildlife (Flather and Hoekstra in press, USDA Forest Service 1988b). The impact of herbivores on riparian vegetation, also a concern, was discussed in the vegetation management section above.

Multiple Species Grazing

Issues

Managing for the needs of livestock, wild herbivores, and other wildlife species were concerns raised by resource managers (Barton and Fosburgh 1986, Flather and Hoekstra in press, USDA Forest Service 1988b). Overgrazing by livestock, overutilization of riparian areas by herbivores, lack of suitable grazers, the lack of proper grazing systems, and the need to manage for both wild and domestic herbivores were among the concerns.

Within the Forest Service planning process, range managers were concerned that the development of allotment management plans (AMP) would be hindered by time/personnel/funding problems (USDA Forest Service 1988b). The development of the AMP is the site-specific planning process designed to meet the resource objectives in the Forest Plan. The standards and guidelines associated with the Forest Plan address the ecological management objectives for plant associations, utilization objectives, and riparian objectives. This need to develop or revise allotment management plans that meet the planning objectives on BLM lands was also raised as a management concern. Difficulties with permit administration and violations of the terms of the permit were also management issues on public lands.

The most important wildlife and fish management issue cited by BLM biologists was the effect of livestock grazing on wildlife habitat (Flather and Hoekstra in press). The deteriorated quality of big game winter range, small game habitats, and riparian communities, as well as threatened and endangered species were issues related to livestock grazing. Because the mandate to manage BLM-administered lands for multiple use is a recent direction, comprehensive information is lacking on the amount and status of wildlife and fish populations and their habitats, and the distribution of threatened and endangered species. This lack of information is inhibiting effective management on BLM-administered lands (Flather and Hoekstra in press).

The suitability and availability of grazers or browsers was another concern of resource managers. Certain lands, because of vegetation or terrain, are more suited to one type of grazer or browser, or to a mix of these animal types. The Rocky Mountain region has a large area of rangeland that is best suited for domestic sheep use, or because of vegetation management purposes, needs a change to browsing animal. This lack of suitable herbivores was also a problem for managing lands infested with certain undesirable plant species. Sheep and goats can graze range infested with woody species, but limited markets restrict the availability of these animals for grazing public lands and restrict an expansion of sheep enterprises within the private sector. Resource managers on BLM lands reported acres of suitable habitat for the desert bighorn, but no animals available to place in these areas.

About 136 million acres of nonfederal rangeland are well-managed, about 134 million acres could be improved by refinements in grazing management, and about 117 million acres need more intensive measures (USDA Soil Conservation Service 1987c). Controlling livestock numbers, and season and duration of grazing could improve the condition of 134 million acres of nonfederal rangeland. The desired vegetation is present on this rangeland, but plant vigor or stands could be improved by such practices as proper grazing use, deferred grazing, planned grazing systems, and fencing and water facilities for improved animal control and grazing distribution. The remaining 117 million acres would require more intensive treatment, such as brush management, range seeding, or erosion control (USDA Soil Conservation Service 1987c).

Economic pressures in the livestock industry have influenced the viability of many livestock enterprises. In 1986, 43% of the beef, hog, and sheep farm/ranch enterprises had negative net cash household incomes (Gee and Madsen 1988). Low livestock prices, high production costs, low land values, and little borrowing power may necessitate a diversification of multiple use within livestock enterprises (Grazing Lands Forum 1987). The Special Advisory Committee to the National Cattlemen's Association reported in 1982 that opportunities for profitable operations through 1990 will go largely to the better informed and more able planners and managers (National Cattlemen's Association 1982). This forecast will probably apply in the near future also.

Opportunities

Management opportunities to enhance the use of herbivores on forest and rangelands exist. For some situations, planning methods or organizational structure are present but limited by funding or personnel. The development of allotment management plans on public lands would facilitate the implementation of desired management objectives, but funding and personnel restrict the number of these plans that can be accomplished.

In other situations, the technology transfer to public and private management limits the optimal use of range and forest lands.

The management of multiple species of grazers and browsers could increase the efficient use of range and forest vegetation (Baker and Jones 1985). Multiple species grazing includes the grazing of one animal after another has already grazed the area, or the grazing of two of more species at the same time. Animal species could include domestic, wild, or animals of both types (Baker and Jones 1985, White 1987). The volatility in the cattle industry has sparked a recent interest in the profitability of wildlife within a ranching operation (Bedell and Rasker 1987, Rollins 1988).

As summarized by Baker and Jones (1985), the advantages of multispecies grazing systems for domestic animals include:

1. *Complimentarity*: Different animal species have different preferences for plant species, differential ability to digest various types of forage, and different patterns of forage harvesting (animal behavior).
2. *Improved pasturerange management and forage production*: Multispecies grazing enhances herbaceous production through increased species diversity and the maintenance of plants in vegetative states.
3. *Parasite management*: Alternating pastures between species helps to break the life cycles of parasites.
4. *Predator control*: Aggressive behavioral differences in grazing animals may help reduce predator losses.
5. *Diversification and income stability*: The risk associated with volatile market prices is spread over a number of outputs rather than a single product.

Multiple species grazing also carries some disadvantages: increased facility costs because of diverse species requirements, potential labor conflicts such as the coincidence of calving and lambing, need for increased management skills in the knowledge of species nutrition, diseases, parasites, breeding practices, marketing, and predator control (Baker and Jones 1985). Although the spread of disease is a concern in a multispecies grazing operation (Davis 1985), certain operations may reduce the likelihood of disease spreading from livestock to wild herbivores. For example, the only new animals annually introduced to a cow-calf operation are bulls which have been carefully chosen and inspected for disease, whereas in a stocker operation, many new animals, calves or yearlings, are bought and placed on the range each year (Cooperrider 1985).

Optimization in a multispecies operation results in an overall gain, rather than the maximization of a single species. Reduced numbers of each species in the operation might result in some loss in volume discounts on services and materials (Baker and Jones 1985). Multiple species management requires a careful evaluation of the range and forest land resource. Otherwise, this management may cause ecosystem deterioration when there is a critical habitat overlap of grazing animals, such as in riparian zones (Schuster 1985).

Research Needs

Resource managers and others associated with range recognize the need to broaden the research objectives for range. Range management must be based on ecological principles and defined in terms of species composition, ecological condition, and the ability to provide a specified sustained level of use. The need to understand the relations between plants, animals, and soil was one of seven research goals developed by the Society for Range Management. Research needs related to the grazing animal and better management systems included: (1) the impact of grazing animals on the morphology and physiology of pasture and range plants, (2) how plant characteristics such as palatability and nutrient value affect livestock behavior, distribution and performance, and (3) the response of grazing animals to micro- and macrochanges in plant communities (Society for Range Management 1989).

Information on the economics of range management, particularly different grazing systems, is a critical need (Society for Range Management 1989, USDA Soil Conservation Service 1987b). Management needs outlined by the Soil Conservation Service stressed the connection between ecological processes and the economics of management (USDA Soil Conservation Service 1987b). Landowner requests for SCS assistance to plan and implement grazing systems led to a recognition of limited information on the effects of grazing systems on soil compaction, infiltration, runoff, erosion, water yield and quality; on plant succession, seedling establishment, nutrient cycling, plant vigor, and plant populations; on appropriate stocking rates, animal performance, and livestock production; and on wildlife habitat response and populations (USDA Soil Conservation Service 1987b). Technology transfer needs of currently available research results were recognized by Society for Range Management (1989).

Livestock as a Vegetation Management Tool

Issues

Restrictions on the use of herbicides have resulted in steadily increasing populations of undesirable plant species. This problem occurs in timber plantations where plant control is desirable to reduce herbaceous and browse vegetation from competing with the planted trees. The problem with respect to herbivore grazing and habitat for threatened and endangered species on rangelands has been discussed in the section above on undesirable plants.

Opportunities

Different livestock species have different forage preferences and under proper management, these preferences can be used to modify the vegetation to meet resource objectives for timber, wildlife, or recreation. One of the

strategies recommended by the work group of the 1985 National Range Conference was to increase and enhance the opportunities to use livestock grazing to manipulate vegetation to meet land management objectives (Dunlop 1987). Livestock grazing has been used to reduce shrub growth which improves summer or winter range for wild or domestic grazers. The use of livestock as a vegetation management tool requires the presence of nutritional forage, consideration of the costs of control, and appropriate livestock for vegetation present. Proper grazing management should be timed to reduce the vigor of competing vegetation, maximize soil moisture and nutrients for desired species, and on tree plantations, to minimize browsing of tree seedlings and reduce trampling (Doescher et al. 1987, Sharrow and Leininger 1982). Sheep grazing reduces browse growth (Sharrow and Leininger 1982), and promotes herbaceous growth of grasses and forbs. On forested sites, this not only benefits the young trees but enhances the nutritional quality of the shrub regrowth for the benefit of the wildlife that return to the area once the sheep have been removed (Pearson 1983, Wray 1987).

Weyerhaeuser Company in southwest Oregon has implemented a grazing program on over 600,000 acres of forestland (Doescher et al. 1987). The Alsea District of the Siuslaw National Forest is testing the use of sheep in Douglas-fir plantations. Cattle grazing in southern pine plantations has also received much study (Pearson 1987). Because of the mixed vegetation and variable topography, ranchers on the Edwards Plateau in Texas have long recognized the value of grazing cattle, sheep, and goats on the same range. After mechanical brush treatment on the Grand Prairie in Texas, a grazing system of cattle was enhanced by Angora goats to consume the browse regrowth (Scifres 1980). Livestock grazing is being used in the Northern region of the United States to maintain openings for wildlife. In studies on the Fremont National Forest in Oregon and the Modoc National Forest in California, heavy early grazing by cattle reduced grass growth and enhanced shrub growth, indicating a potential tool to improve decadent bitterbrush on Great Basin deer winter ranges (Neal 1982). Grazing cattle and horses in Utah improved shrub habitat for wild herbivores also (Urness 1982).

Research Needs

Research needs for the use of livestock as vegetation management tools include better information on the type and kind of livestock capable of controlling different competing vegetation, such as browse under timber plantations and undesirable plants on rangelands (Society for Range Management 1989, USDA Forest Service 1988b). Range resource managers identified the need to define how a change in livestock type can manipulate the vegetation composition to improve other resource values, such as wildlife habitat (USDA Forest Service 1988b).

SOCIAL ENVIRONMENT

Issues

As the United States becomes increasingly urbanized, more people from urban areas will influence management in rural areas. Social issues raised by range managers included the public's perception about range and livestock and the current and future direction of the range profession.

Range resource managers stressed the importance of promoting, internally and externally, the perspective that range management is the science and art of managing range vegetation for multiple use outputs (USDA Forest Service 1987c). Unfortunately, many people perceive that range and range managers are only concerned with livestock. Busby (1987) criticized the Society for Range Management for narrowly directing its efforts only toward livestock use of rangelands. Resource managers stressed that livestock can serve as a management tool to modify vegetation on range and forest land as a replacement for chemical control, but this option is often not available because of public resistance to livestock grazing on public lands.

Animal rights and animal welfare issues were also concerns. Animal welfare concerns have fostered the development of newly formed animal care committees on many university campuses, the passage of the federal Dole/Brown Bill ("Improved Standards for Laboratory Animals Act"), revisions of the Public Health Service's animal care guidelines, and withdrawal of funding from institutions found in violation of animal care regulations (Schmidt 1987). Although these actions have focused on laboratory animals, animal welfare groups are also concerned about commercial meat and egg production (i.e., egg production using hens in battery cases, and veal production methods), and wildlife management (i.e., hunting and trapping).

Enrollment in natural resource programs has declined as a result of few entry-level jobs being available in the late 1970s. Undergraduate enrollment in wildlife programs in 1985 was 40% lower than the peak years of 1974-77 (Hodgdon 1987). Similarly, the 1985-86 enrollment in forestry technician programs was 40% of the 1977-78 enrollment (Martin and Jahnke 1987). Similar statistics for range programs were not available.

The issue of career advancement within the range profession concerned the upward mobility within an agency as well as the proper training for natural resource management work. Because career ladders do not exist for range conservationists within public agencies in some areas of the United States, it is difficult to find and keep competent people in range management.

Kennedy (1987), in examining career development of range conservationists in their first 3 years with the Forest Service, noted that working "out-of-doors" dominated the job motivations of these young professionals. University curriculums emphasize field methods, but, very few of the range conservationists surveyed spent over 50% of their time in the field; a significant proportion was spent in planning/administering and coordinating

between the Forest Service and their clients or other agencies (Kennedy 1987). Public involvement has become a significant part of natural resource management since the environmental legislation of the 1970s.

Opportunities

The need for increased communication between land managers and the public fostered a special session at the 1988 Annual Meeting of the Society for Range Management which dealt with the successful management of public rangelands (Hall and Hampton 1988). The need to communicate the broader concepts of range management within and without NFS was also identified in the National Range Workshop (USDA Forest Service 1987a). This need to enhance communication was also recommended by the 1985 National Range Conference which brought together ranchers, range professionals, agribusiness leaders, environmentalists, producer associations, and others interested in rangelands. Specifically, the group recommended that efforts be undertaken to inform the public with accurate and unbiased information about rangeland uses (Dunlop 1987). This recommendation stressed that the public needs to know and understand that the benefits achieved through proper livestock grazing practices include sustained resource values, such as soil productivity and water quality, wildlife habitat, threatened and endangered flora and fauna, ecological diversity, and forage production for domestic and wild herbivores (Dunlop 1987).

Research Needs

Increased urbanization in the United States will mean that a growing percentage of the population will have little or no direct contact with natural resource management. In California where urbanization is proceeding rapidly, public information and education programs for kindergarten through 12th grade are needed to demonstrate the relevance of California's natural resources to the sustained well-being of urban populations (California State Board of Forestry, Committee on Research 1987). At the university level, Kennedy (1987) stressed that the increased interaction between resource managers and the public makes it even more critical that range conservation students be better educated and role-modeled to understand, appreciate, and master the internal politics of decision-making.

MULTIRESOURCE AND MULTI-AGENCY PLANNING

The management of range vegetation to produce multiple resource outputs was a concern raised by resource managers (USDA Forest Service 1988b). The need to manage forest and rangelands for wild and domestic herbivores was stressed by wildlife and range managers (Flather and Hoekstra in press, USDA Forest Service 1988b). Extensive resource management was seen as an efficient way to ensure water quantity and quality from forest and rangelands (Guldin in press). Not only are these problems multiple-resource oriented, but they are also multi-agency, as land ownerships often form a checkerboard pattern on the landscape.

Issues

The need to address range management from a multiple output perspective has been stressed in this chapter. On public lands, resource managers were concerned that the need to plan for the production of a mix of resource outputs from the land base was not being adequately addressed (Flather and Hoekstra in press, USDA Forest Service 1988b). Problems associated with the timing of management activities or the spatial distribution of these management activities are given insufficient attention because of insufficient time or personnel, or lengthy planning horizons. The loss of habitat on private lands for wildlife species places an increasing importance on nearby public lands to supply food, cover, and water. These remaining lands may have previously supplied only a portion of the total annual feed mix for these wildlife species, and now must supply a year-round feed mix. Examples can be given also where recreational developments on public lands force wildlife onto private lands, resulting in a seasonal forage deficiency, or increased crop damage. Conflicts also exist between wildlife, livestock grazing, and mineral development, and between water rights authority and wildlife in wetland areas. The Forest Service and the BLM must manage for a multiple set of resource outputs, and planning becomes increasingly important to resolve objectives for land management.

Many private landowners are in agreement with the multiple use concept but are concerned with its implementation (Grazing Lands Forum 1987). Specifically, issues of concern included poor enforcement of vandalism laws on private land, economic pressures to convert agricultural lands to developed uses, lack of cooperation between state and federal agencies concerning fish and wildlife habitat, allocation of much of agency funds for single-use management, and economic returns favoring commodity over noncommodity uses (Grazing Lands Forum 1987).

Government crop programs which temporarily change the vegetation composition have an impact on the mix of outputs that can be produced from a landscape composed of many different ownerships (Joyce and Skold 1988). These programs impact the forage and habitat for grazers and browsers, water runoff, and habitat for wildlife. The most recent program, the Conservation Reserve Program, will increase permanent vegetation cover for 10 years by 45 million acres (Chapter 2). State wildlife and fish managers saw this shift in vegetation cover as potentially benefiting small game, and in some places, big game. For the duration of the contract, this land cannot be grazed by livestock. Many questions concerning the impact of this program and future agricultural programs arise. Because these lands potentially represent

a large supply of forage, a concern has been raised on the potential impact on the livestock sector, and on releasing this forage supply at the end of the contract period. In addition, previous research suggests that any gains in wildlife populations would be jeopardized if cover were to shift dramatically after the program was ended (Joyce and Skold 1988).

Opportunities

Many successful examples can be cited where diverse, and often conflicting, interests have been brought together to arrive at common understanding and consensus in planning and implementing multiple uses. These examples include the Coordinated Resource Management Planning programs, the Experimental Stewardship Program, the Northwest Watershed Improvement Coalition, and the Oregon Watershed Improvement Coalition (Demarchi 1988, Grazing Lands Forum 1987).

Oregon range evaluation project—a case study in multiresource planning.—The Accelerated Range Program was initiated to conduct large-scale testing to confirm or adjust multiresource assumptions made in a nationwide study of rangeland productivity (Sanderson et al. 1988). The Grant County Resource Council proposed that Grant County be designated an "evaluation area" under the Forest and Rangeland Renewable Resource Planning Act, and in 1976, Congress appropriated $1.4 million to initiate the Oregon Range Evaluation Project (EVAL). The objective of EVAL was to determine the most cost-effective way to increase herbage and browse for livestock and to determine the effects of range management strategies on water quantity and quality and the consequences for the local economy (Sanderson et al. 1988).

The EVAL project was divided into four major elements: (1) Implementation—selecting private landowners to cooperate with EVAL, developing coordinated resource management plans, and establishing range management practices on public and private land; (2) Maintenance—maintaining the improvements adequately over the study period; (3) Monitoring—collecting baseline data and evaluating the effects of grazing management strategies on environmental, economic, and social resources, and (4) Reporting—providing the research results to all parties (Sanderson et al. 1988). The Forest Service (including the NFS, the State and Private Forestry, and Research) was the lead agency. Primary cooperating agencies and groups included the SCS, the Agricultural Stabilization and Conservation Service, the BLM, Oregon Department of Forestry, Oregon Department of Fish and Wildlife, Oregon State University Extension Service, and private landowners. Many other organizations and institutions cooperated.

The success of the EVAL project is marked by the excellent interagency cooperation and the cooperation provided by the private landowners. The project facilitated the development and implementation of 22 coordinated resource management plans and 21 long-term agreements. Over 1,000 range practices were established on 58,000 acres of private land and on 283,000 acres of public land. More ranchers are now requesting technical assistance than before the EVAL project, and some range practices are being initiated with the benefit of matching funds (Sanderson et al. 1988). The results of more than 100 theses, reports, and publications will provide private landowners, land managers, and environmental groups with economic and environmental information useful in future range management.

Experimental stewardship programs.—Cleary (1988) described the Modoc/Washoe Experimental Stewardship Program in northeastern California and northwestern Nevada as a successful example of coordinated resource management. Participants in this program viewed range management as more comprehensive than livestock management and chose to accommodate all public land uses where possible. Program participants included members from the livestock industry, timber industry, county governments, university range science departments, county Extension Service, SCS, resource conservation districts, Agricultural Stabilization and Conservation Service, Audubon Society, state game departments, state agricultural departments, Fish and Wildlife Service, the National Wildlife Federation, the BLM, and the FS. The long-term goal was to foster cooperation and coordination among the participants to achieve: (1) environmental improvement; (2) integrated and improved management of all ownerships; and (3) through improved management, long-term stability of the economy.

Management and Research Needs

The new and diverse demands being placed on range and forest ecosystems imply a continual need to further understand the ecology of these systems and to develop new management strategies to produce the multiple resource outputs demanded from these wildlands.

Opportunities to address multiple resource planning exist, particularly if state and county coordination can be strengthened (USDA Forest Service 1988b). Demarchi (1988) stated that coordinated resource management planning (CRMP) could be more successful if implemented after the development of a strategic land use plan in which decisions were made concerning the pattern of land use and how much of each use would be allowed within a planning unit. The CRMP focuses on the operational planning, that is, the how and by whom the goals identified in the strategic land use plan are to be achieved.

The desired situation with respect to multiple resource management, as reported in the Grazing Lands Forum (1987), was that all interested groups affected by this type of management would work together voluntarily to share information and arrive at consensus on management action. The recommendations to achieve this situation included: repeatedly invite all interested parties to participate in the planning process, expand the use of successful conflict resolution processes, inform and

assist potential users in conflict resolution, encourage educational and governmental institutions to emphasize multiple use values and coordinated planning, support the development of instructional aids for cooperative multiple use planning, and identify and hold meetings at demonstration sites (Grazing Lands Forum 1987). Opportunities exist also to increase the information transfer between research and management. Demonstration projects such as the EVAL project help increase the flow of research results to management.

Previous research has focused on single resource management and only recently, have multiresource projects begun to unravel the complexities of multiresource production. Research to increase, through cost effective measures, the output of multiple range resources has been recognized as an important research priority (Experiment Station Committee on Organization and Policy 1988, Society for Range Management 1989, Western Agricultural Research Committee 1985). Methods are needed to manipulate the plant community through biological mechanisms such as allelopathy, germplasm improvement, livestock, and introduced competition (Society for Range Management 1989). Also needed is an improved understanding of nutrient cycling processes and critical physiological characteristics of important forest and range plants (Western Agricultural Research Committee 1985).

Understanding and enhancing the productive capabilities of forest and range ecosystems was one of the research issues raised by the Agricultural Experiment Stations (Experiment Station Committee on Organization and Policy 1988). With respect to agricultural and forest land use, the stations saw the need to assess the implication of expanding wildlife enterprises and other recreation uses of agricultural, range, and forest lands, and to develop land use planning systems for the wildlife/rural/urban interface. The implications of changing land use on future forest and rangeland resource production were also identified as an urgent research topic by the California State Board of Forestry (1987). The future size, shape, and distribution of forest and rangeland area will be affected by landowner decisions. How zoning, taxes, population growth, and regulations affect these landowner decisions is not well-understood. Declines in timber and range production by the break-up of commodity-based ownership tracts and by restriction of management practices on and adjacent to residential parcels was a concern of the Board of Forestry (California State Board of Forestry 1987). Smaller parcels and expansion of the urban-wildland interface may reduce wildlife habitat area, create barriers to wildlife migration, enhance sediment losses, and complicate wildfire control problems. Research is needed to determine the long-term trends and to quantify the potential effects on timber and rangeland production, wildlife, rural services, and rural economics (California State Board of Forestry 1987).

Further, the impacts on vegetation are no longer just site-specific. An understanding is needed of the cumulative effects of management within a watershed or a region. Environmental changes, such as increased atmospheric deposition, increased carbon dioxide levels, or elevated air temperatures may have major effects on the structure, function, and productivity of forest and range ecosystems. Future research is needed to understand these possible effects and how forest and range management activities could be altered to sustain forest and range ecosystem health and productivity (Experiment Station Committee on Organization and Policy 1988, USDA Forest Service 1988a).

High-quality data bases and information management systems are needed to permit more knowledgeable policy discussion on land use alternatives (California State Board of Forestry 1988, Experiment Station Committee on Organization and Policy 1988, Flather and Hoekstra in press, USDA Forest Service 1988b). With respect to rangelands, information about the type and condition of vegetation is not complete for all ownerships. This lack of information limits an assessment of the range resource. The Agricultural Experiment Stations identified needed research to understand the biological and ecological concepts applicable to multiuse management of rangelands and pasturelands, and to develop information systems and decision models for users of these lands (Experiment Station Committee on Organization and Policy 1988).

The low economic return on rangelands influences its placement in research priorities. In evaluating the potential success of biological control on pasture/range species, range plants receive a lower priority in research (USDA Agricultural Research Service 1984). In prioritizing the 21 research initiatives, the Agricultural Experiment Stations ranked Productivity of Range and Pastureland the 18th priority, surpassing the initiative on Forest Productivity by only 1 rank (Experiment Station Committee on Organization and Policy 1988). As more resources are demanded from these lands, it will become increasingly important to understand the underlying ecological processes of rangelands.

MANAGEMENT OBSTACLES

Management obstacles are those factors that prevent implementation of effective management opportunities for the range resource. The most common obstacles identified by range resource managers were inadequate funding, inadequate staffing, lack of qualified personnel, and lack of knowledge. These factors were also the most common obstacles cited by wildlife and fish managers (Flather and Hoekstra in press).

Inadequate funding affects all aspects of range management and research. Lack of funds and technology affect the number of management alternatives available to the resource manager. Between 1980 and 1985, in constant (inflation adjusted) dollars, the Forest Service budget declined by 16%, funding for range management on national forests declined by 25%, funding for wildlife and fish management on national forest declined by 9% (Barton and Fosburgh 1986).

Although lack of funding is often the cause for the lack of personnel, declining enrollments and number of graduates with natural resource degrees has resulted in

a short supply of potential resource managers. In addition, specialists for threatened and endangered species are also in short supply. An interdisciplinary approach in planning requires management experts in a variety of fields. Traditional attitudes of personnel/public limit new and creative approaches to land management.

The need for knowledge to provide the best management was discussed in the opportunities sections above. Overcoming this lack of knowledge requires research and the transfer of research results to managers. Knowledge also refers to the awareness and understanding of the public's attitudes and values with respect to the range resource. The need for increased communication between resource managers and the public was recognized as very important. The public must understand the production requirement for a mix of resource outputs and the proposed management for that land. This shared understanding is important to resolve resource conflicts. Public information and education programs, including demonstration projects, are opportunities to increase the communication links. The demands on the range resource are increasingly broadening which expands the number of people and interests using the range resource. Resource managers need to be aware of the changing demand on the range resource to better meet the public's needs.

SUMMARY

Potential shifts in forage production could significantly affect the availability and utilization of forage by wild and domestic herbivores. Increasing demands for recreation and water production from public lands will influence range management. The expected rise in forage demand, coupled with relative declines in public forage and irrigated pastures, suggests that range management on private lands will intensify. A future in which resource use intensifies poses the possibility that our Nation's ecosystems will not likely improve in condition or productivity. The management issues associated with the range resource are now broader than livestock grazing.

Management issues are grouped into four categories: the management of range vegetation; the management of grazers and browsers, both wild and domestic; social issues; and planning. Vegetation management issues revolved around providing the type of vegetation on public and private lands necessary for the production of multiple outputs. Problems ranged from inadequate seasonal forages for wild and domestic herbivores, the expired life-time of existing range improvements, reductions in habitat and forage availability, riparian vegetation, and the control of undesirable plants. Opportunities in vegetation management include grazing systems, stream management for riparian areas, the interseeding of native/introduced species to lengthen the seasonal availability of forage, and the use of biological control agents including livestock. The development and adoption of management practices and technologies will become significant factors in the future of the range resource. Research issues included the lack of knowledge about the ecology of vegetation and the need for technology transfer from research to management.

The need to provide food and habitat for wildlife, wild horses and burros, and livestock raises the issue of the management of grazers and browsers. The number of animals, the seasonal distribution of these animals, the availability of suitable grazers and browsers for each range ecosystem, and the management of these animals on public lands are components of this management issue. Opportunities exist to increase the efficient use of range and forest vegetation and control undesirable plants through the management of multiple species of grazers and browsers.

The value of the natural environment is increasingly in the public's mind, and society's ideas about range will determine the future use of this resource. These social issues point to the need for increased communication between land managers and the public, and for adequately trained range managers. Opportunities exist to communicate the values received from a healthy plant association, the livestock role in maintaining the desired ecological status, and an understanding that proper livestock grazing practices can achieve desired resource benefits.

Whether legally mandated or profit motivated, the desire to produce a mix of resource outputs from forest and rangelands raises the issue of planning. Problems in planning include the design of management for multiple resources, coordination between adjacent or checkerboard ownerships, coordination of timing or spatial distribution of management activities, insufficient planning time, difficulties of quantifying the relationship between current actions and future consequences, economic pressures to convert nonfederal agricultural lands to developed uses, and economic returns favoring commodity over noncommodity uses. Many successful examples can be cited where diverse, and often conflicting, interests have reached consensus in planning and implementing multiple uses.

Research is needed to increase, through cost effective measures, the output of multiple resources from rangelands and forests. Methods are needed to manipulate the plant community through biological mechanisms. Long-term productivity will be sustained only with an improved understanding of nutrient cycling processes, critical physiological characteristics of important forest and range plants, and the response of ecosystems to disturbance.

An understanding is needed of the cumulative effects of management within a watershed, forest, or a region. The future size, shape, and distribution of forest and rangeland area will be affected by land management decisions, and how these decisions are affected by zoning, taxes, population growth, and regulations is not well-understood. Smaller parcels and expansion of the urban/wildland interface may reduce wildlife habitat area, create islands of suitable forage for grazing, create barriers to wildlife migration, increase sediment losses, and complicate wildfire control problems. Research is needed to determine the long-term trends of land use

changes and to quantify the potential effects on rangeland production, wildlife, rural services, and economics. Toward this end, a need exists to develop high-quality data bases, information management systems, and decision models to permit more knowledgeable policy discussion on land use alternatives.

Management obstacles are those factors that prevent implementation of effective management opportunities for the range resource. The most common obstacles identified by range managers were lack of knowledge, inadequate funding, inadequate staffing, and lack of qualified personnel. The actualization of the opportunities for range management requires a commitment of those involved in natural resource management.

CHAPTER 7: IMPLICATIONS OF THE RANGE ASSESSMENT FOR FOREST SERVICE PROGRAMS

RELATIONSHIP BETWEEN ASSESSMENT AND PROGRAM

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), as amended, directs the Secretary of Agriculture to prepare a comprehensive, long-range Assessment of the Nation's renewable resources and to develop a Program for Forest Service activities. The technical supporting documents for range, timber, wildlife, recreation, minerals, and water identify opportunities to balance supplies of renewable resources to meet projected demands. The Assessment presents the findings of these technical supporting documents and summarizes the implications for the Program. Opportunities outlined in the Assessment (Darr in press) help set the scope of the national goals to guide development of the Program. The Program recommends courses of action, based on the findings of the Assessment, for the management and administration of the National Forest System (NFS), for Forest Service Research, and for assistance to state forestry organizations and other cooperators through State and Private Forestry activities. This chapter discusses briefly the implications of this Range Assessment to the 1990 Program of the Forest Service.

FOREST SERVICE PROGRAMS

Forest Service activities are divided into three major areas: National Forest System, State and Private Forestry, and Research. The NFS manages 156 National Forests, 19 National Grasslands, and 16 Land Utilization projects covering a total of 191 million acres. The State and Private Forestry program extends financial and technical assistance to states, and through them, to private landowners, in the application of forest management practices on private lands. Eight Forest Service Experiment Stations and a Forest Products Laboratory conduct research to solve important problems related to the protection, management, and wise use of forest and rangelands through development of knowledge and technology.

The Forest Service receives operating funds from Congress and from various cooperator deposits (USDA Forest Service 1987d). Operations such as timber sales on NFS lands generate receipts. Other receipts from these lands are collected from grazing and recreation fees and mineral leases and permits. In 1986, $1.32 billion was received from users of NFS lands, while expenditures totaled $1.71 billion. Eighty-three percent of the revenue in 1986 was from timber receipts which included cash, deposits, and roads in lieu of cash. The second largest source of revenue was receipts from mineral leases, royalties, sales, and bonus bids. Grazing leases provided 1% of the Forest Service revenue (fig. 59).

Expenditures for the NFS measured nearly 83% of the Forest Service budget. The Working Capital Fund which is used to replace vehicles and heavy equipment amounted to 4% of the expenditures; 6% of the expenditures were allocated to Research, and 3% to State and Private Forestry. Human Resource Programs, which expended 4% of the Agency budget, provided job opportunities and training for youths, the unemployed, underemployed, economically disadvantaged, and the elderly, while carrying out high-priority conservation work.

The work force within the Forest Service is distributed across program areas as follows: 92.2% in NFS, 7.3% in Research, and 0.5% in State and Private Forestry (fig. 60). Technical occupations account for 57.3% of the work force; the largest portion is for forestry technicians. Professional staff account for 23.7% of the Agency's work force; foresters and civil engineers are the largest of the professional occupations.

IMPLICATIONS FOR THE 1990 PROGRAM

The 1985 Program provided guidance for the administration of NFS, State and Forestry Programs, Research, and other Forest Service activities through 2030 (USDA Forest Service 1986a). The 1985 RPA Program identified a number of resource options recommended by the Secretary of Agriculture to permit consideration of both the current federal deficit situation and the Forest Service long-term resource goals. These options responded to the long-term renewable resource needs of the American people as described in the Assessment supplement (USDA Forest Service 1984a). The 1985 Program recognized the importance of nonfederal lands in meeting long-term resource needs and emphasized the contribution needed from research to take full advantage of the national resource opportunities.

The specific goal for range identified in the 1985 Program was to "provide forage to promote the economic stability of dependent livestock producers and rural

public lands was the constraint associated with managing this mobile resource over a land base with intermingled and fragmented land ownership (Flather and Hoekstra in press). Coordinated resource management has been successfully used to address these multiple ownership planning problems (Chapter 6).

The Forest Service must continue to take steps toward a broader view of range management and range management practices—beyond traditional forage and livestock benefits—to an overall perspective that includes a full range of values. To meet these new challenges, the Forest Service is reviewing its range management policy, objectives, and delegations of authority (Comanor 1988a). This examination includes day-to-day operations and methods of range analysis and planning. A full range of values are contemplated to measure range management goals and accomplishments in terms that more accurately portray, both to the administrator and to the public, the broader scope of range vegetation management.

State and Private Forestry

Technical and financial assistance is provided to states by the State and Private Forestry programs to help protect and improve the productivity and management of the nonindustrial private forest lands (USDA Forest Service 1987d). The Cooperative Forestry Assistance Act of 1978 authorized the Secretary of Agriculture to cooperate with state foresters and provide assistance in a variety of forest-related activities: (1) fire prevention and control, (2) prevention and control of forest insects and diseases, and (3) forest management and utilization (USDA Forest Service 1987d). The latter activity can benefit wildlife and range programs through habitat and range improvement programs.

The Range Assessment identified that much of the increase in range forage supply will come from private lands. The Range Assessment also assumed that these private lands will be managed more intensively. The profitability of ranching will determine the actual supply from private lands. The Soil Conservation Service might consider the extent to which technical assistance would facilitate range forage production on private lands. On forested lands, technical assistance through State and Private Forestry programs could expand the implementation of timber management practices in an agroforestry context. The need to diversify outputs from ranching/farming enterprises has led to an interest in multiple use management (Chapter 6). Technical assistance is needed to facilitate the implementation of multiple use management practices on private lands. This implication suggests the need to coordinate resource management among agencies providing technical assistance on rangeland such as the Soil Conservation Service, and the Extension Service.

Forest Service Research

Forest Service research comprises 9 major areas of research: forest fire and atmospheric sciences; forest insect and disease; forest inventory and analysis; renewable resources economics; trees and timber management; watershed and rehabilitation; wildlife, range, and fish habitat; forest recreation; and wood products and harvesting. As required by Title XIV of the Agriculture and Food Act of 1981, Forest Service research is planned jointly with the 61 forestry schools through the USDA Cooperative State Research Service. Research goals are directed toward increasing the productivity of public and private forest and rangeland while maintaining or enhancing environmental quality.

In an official policy paper released by the Secretary's (Agriculture) Office of Science and Education on March 22, 1982, the following responsibilities were stressed by the Administration and Congress as appropriate Federal agricultural research responsibilities:

a. Fundamental approaches that are beyond the risk-taking capacity of the private sector.
b. Areas needing systems approaches, high-cost integrated multidisciplinary approaches, or mega-problems (national/global scope) which are beyond the capability of other sectors.
c. Programs that other areas will not address or which cannot be equally or better accomplished elsewhere. This particularly relates to industry capability and responsibility.
d. Programs which because of their high cost, high priority, or regional, national, or global scale require government management and leadership but do not preclude participation by other sectors.
e. Programs mandated by Congress.
f. Programs required by U.S. Department of Agriculture, such as technical and educational support for action agencies.

Based on this policy statement, the 1985 Program Update concluded that high-priority Forest Service research should be continued, with focus on new research such as biotechnology and more fundamental research, improved information and analytical systems for analysis of domestic and international timber supply-and-demand trends, and research requiring major integrated multidisciplinary efforts of national or international scope. Other major focus points included economic efficiency of forest resource management, atmospheric deposition, water quality and yield, and forest resource protection from fire, insects, and disease (USDA Forest Service 1986a). Research direction identified for range was as follows:

> Greater productivity of range resources is needed and can be realized through genetic improvement of range plants, broader understanding of range ecology, improved grazing management systems, and development of environmentally safe noxious weed control technology.

The Program identified specific opportunities to increase rangeland productivity through research such as forage plant improvement, integration of forage management with other land management strategies, and use of fire for improving rangeland growing conditions (USDA Forest Service 1986a).

This assessment points out the need for greater productivity recognizing the broader demands by the American people on the range resource. Range ecosystems have been managed on the basis of low inputs. Future resource output demands from these systems will require an intensification of management or these systems will not likely improve in condition or productivity. A clear need exists to increase our understanding of basic biological and economic relationships for the purpose of developing new technology to integrate and enhance range resource values on intensively managed rangelands. Low-cost range improvement practices are needed in areas where profit is low. The implications to over-use of the range resources are long-term, particularly in the arid west.

This assessment points out several range research needs:

1. the need to develop vegetation management for multiple resource production from rangelands,
2. the need to define opportunities for multiple grazing species management of rangelands,
3. the need to define the ecological and economical opportunities for using livestock as a vegetation management tool in a broader number of ecosystems,
4. the need to develop quantitative methods to analyze the economic and environmental consequences of increasing multiple resource demand from rangelands on a site-specific basis and at larger scales; this includes the need for better resource inventories,
5. the need to quantify and monitor local and regional impacts of multiple resource management across ownerships.

Range vegetation management must be based on ecological principles and be defined in terms of species composition, ecological condition, and the ability to sustain use. Research needs include understanding of the ecology of rangelands and the ecosystem's response to natural and human-caused disturbances. The nature of human-caused disturbances includes intentional management as well as unintentioned human disturbances, such as the introduction of undesirable plants. The role that biotechnology can play in controlling these disturbances is an important range research goal, as is the role that range vegetation can play in providing genetic material with desired attributes such as drought or pest resistance. The unique aspects of the riparian zone are also a research topic of high priority. Opportunities exist to integrate the disciplines of timber, watershed, wildlife, range, fisheries, and soils research to address the complex interrelationships among plants, animals, and physical factors in riparian zones.

The management of multiple species of grazers and browsers can increase the efficient use of range and forest vegetation. Research needs in this area include the compatibility of animal types, forage requirements, and grazing management systems. Additional research is needed on the economics of multiple species grazing. The role of livestock as a management tool offers opportunities to attain land management objectives, particularly where environmental concerns have shifted the availability of management practices.

As the intensity of land use increases, so does the need to develop quantitative methods to analyze the consequences of increasing resource demand from rangelands on a site-specific basis and at larger scales. The urban encroachment on rangeland not only increases the conflicts between urban and range land activities, but places increased importance on rangeland for wildlife, livestock, recreation, and water production. Linking site-specific activities within the context of other land uses/management activities at a larger scale (such as a watershed, forest, across ownerships, or within a region) will be important in evaluating the consequences of land management activities on the resource outputs from rangeland. Risser et al. (1984) summarized the need for multiple-scale resource analyses by concluding that informed resource planning can no longer be based solely at the site level, but must develop methodologies for examining the interaction of resources across larger geographic areas or landscapes. Future land management decisions will determine the size, shape, and distribution of parcels of land with forest and range vegetation, and these attributes will determine their future viability for resource production.

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APPENDIX A: COMMON AND SCIENTIFIC NAMES OF PLANTS (PRIMARY SOURCE: USDA SOIL CONSERVATION SERVICE. 1982. NATIONAL LIST OF SCIENTIFIC PLANT NAMES. SCS TP 159 2 VOL.)

Common name	Scientific name
Acacia	*Acacia* spp.
Alder	*Alnus* spp.
Apache pine	*Pinus engelmannii*
Arizona cypress	*Cupressus arizonica*
Ash	*Fraxinus* spp.
Aspen	*Populus tremuloides*
Baldcypress	*Taxodium distichum*
Balsam fir	*Abies balsamea*
Barbwire Russian thistle	*Salsola paulsenii*
Basswood	*Tilia* spp.
Beech	*Fagus grandifolia*
Birch	*Betula* spp.
Bitterbrush	*Purshia tridentata*
Black grama	*Bouteloua eriopoda*
Black oak	*Quercus kelloggii*
Blackbrush	*Coleogyne ramosissima*
Blackgum	*Nyssa sylvatica* var. *sylvatica*
Blue grama	*Bouteloua gracilis*
Blue oak	*Quercus douglasii*
Blue spruce	*Picea mariana*
Bluestem	*Andropogon* spp., *Bothriochloa* spp., *Scizachyrium* spp.
Bristlecone pine	*Pinus aristata*
Buffalo gourd	*Cucurbita foetidissima*
Buffalograss	*Buchloe dactyloides*
Buffelgrass	*Cenchrus ciliaris*
Bulrush	*Scirpus* spp.
Burroweed (white bursage)	*Ambrosia dumosa*
Bursage	*Ambrosia deltoidea, A. dumosa*
Canada thistle	*Cirsium arvense*
Canyon live oak	*Quercus chrysolepis*
Ceanothus	*Ceanothus* spp.
Ceniza	*Leucophyllum frutescens*
Cheatgrass	*Bromus tectorum*
Chestnut oak	*Quercus prinus*
Chihuahua pine	*Pinus leiophylla*
Coast live oak	*Quercus agrifolia*
Coastal true fir	*Abies amabilis, A. procera*
Cordgrass	*Spartina patens, S. pectinata*
Cottonwood	*Populus fremontii*
Creosotebush	*Larrea tridentata*
Crested wheatgrass	*Agropyron desertorum*
Cypress	*Taxodium* spp., *Cupressus*
Curly mesquite	*Hilaria belangeri*
Dalmatian toadflax	*Linaria dalmatica*
Diffuse knapweed	*Centaurea diffusa*
Diggerpine	*Pinus sabiniana*
Douglas fir	*Pseudotsuga menziesii*
Dyers woad	*Isatis tinctoria*
Eastern hemlock	*Tsuga canadensis*
Eastern white pine	*Pinus strobus*

Common name	Scientific name
Elm	*Ulmus* spp.
Engelmann spruce	*Picea engelmannii*
Fescue	*Festuca* spp.
Fir	*Abies* spp.
Flowering dogwood	*Cornus florida*
French broom	*Cytisus monspessulanus*
Galleta	*Hilaria* spp.
Gopher plant	*Euphorbia lathyris*
Gorse	*Ulex europaenus*
Grama	*Bouteloua* spp.
Grand fir	*Abies grandis*
Greasewood	*Sarcobatus vermiculatus*
Green ash	*Fraxinus pennsylvanica*
Guayule	*Parthenium argentatum*
Gumweed	*Grindelia* spp.
Halogeton	*Halogeton glomeratus*
Hawthorn	*Crataegus* spp.
Hemlock	*Tsuga* spp.
Hickory	*Carya* spp.
Hoary cress	*Cardaria draba*
Interior live oak	*Quercus wislizenii*
Italian thistle	*Carduus pycnocephalus*
Jack pine	*Pinus banksiana*
Jeffrey pine	*Pinus jeffreyi*
Jojoba	*Simmondsia chinensis*
Juniper	*Juniperus* spp.
Kentucky bluegrass	*Poa pratensis*
Kudzu	*Pueraria lobata*
Larch	*Larix laricina*
Laurel oak	*Quercus laurifolia*
Leafy spurge	*Euphorbia esula*
Lehmans lovegrass	*Eragrostis lehmanniana*
Limber pine	*Pinus flexilis*
Little bluestem	*Schizachyrium scoparium*
Live oak	*Quercus virginiana*
Loblolly pine	*Pinus taeda*
Lodgepole pine	*Pinus contorta*
Longleaf pine	*Pinus palustris*
Longleaf uniola	*Chasmanthium sessiliflorum*
Mangrove	*Avicennia* spp.
Maple	*Acer* spp.
Matchweed (Snakeweed)	*Gutierrezia sarothrae*
Mesquite	*Prosopis juliflora*
Mountain big sagebrush 'Hobble Creek	*Artemesia tridentata* ssp. *vaseyana*
Mountain hemlock	*Tsuga mertensiana*
Musk thistle	*Carduus nutans*
Northern red oak	*Quercus rubra*
Oak	*Quercus* spp.
Overcup oak	*Quercus lyrata*
Paloverde	*Parkinsonia florida, P. microphylum*
Paper birch	*Betula papyrifera*
Pecan	*Carya illinoensis*
Perennial peppergrass	*Lepidium latifolium*
Perennial sowthistle	*Sonchus arvensis*
Persimmon	*Diospyros virginiana*
Pine	*Pinus* spp.
Pinehill bluestem	*Schizachyrium scoparium* var. *divergens*

Common name	Scientific name
Pinyon pine	*Pinus edulis*
Plumeless thistle	*Carduus acanthoides*
Poison hemlock	*Conium maculatum*
Pond cypress	*Taxodium distichum*
Ponderosa pine	*Pinus ponderosa*
Port Orford cedar	*Chamaecyparis lawsoniana*
Post oak	*Quercus stellata*
Prickly pear cactus	*Opuntia* spp.
Purple starthistle	*Centaurea calcitrapa*
Rabbitbrush	*Chrysothamnus* spp.
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red spruce	*Picea rubens*
Redwood	*Sequoia sempervirens*
Russian knapweed	*Centaurea repens*
Russian thistle	*Salsola iberica*
Sagebrush	*Artemisia* spp.
Saguaro	*Carnegiea* spp.
Saint Johnswort	*Hypericum perforatum*
Saltbush	*Atriplex* spp.
Saltcedar	*Tamarix pentandra*
Saltgrass	*Distichlis spicata*
Sand bluestem	*Andropogon*
Saw grass	*Cladium jamaicense*
Saw palmetto	*Serenoa repens*
Scotch broom	*Cytisus scoparius*
Sedge	*Carex* spp.
Serviceberry	*Amelanchier alnifolia*
Shadscale	*Atriplex confertifolia*
Shin oak	*Quercus mohriana*
Shortleaf pine	*Pinus echinata*
Side oats grama	*Bouteloua curtipendula*
Silver buffaloberry	*Shepherdia argentea*
Sitka spruce	*Picea sitchensis*
Skunkbush sumac	*Rhus trilobata*
Slash pine	*Pinus elliottii*
Slenderflower thistle	*Carduus tenuiflorus*
Smooth brome	*Bromus inermis*
Snakeweed	*Gutierrezia sarothrae*
Snowberry	*Symphoricarpos albus*
Spotted knapweed	*Centaurea maculosa*
Spruce	*Picea* spp.
Subalpine fir	*Abies lasiocarpa lasiocarpa*
Subterranean clover	*Trifolium subterraneum*
Sugar maple	*Acer saccharum*
Sugar pine	*Pinus lambertiana*
Sugarberry	*Celtis laevigata*
Swamp tupelo	*Nyssa sylvatica* var. *biflora*
Sweet bay	*Magnolia virginiana*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus* spp.
Tall larkspur	*Delphinium* spp.
Tansy ragwort	*Senecio jacobeae*
Tarbush	*Flourensia cernua*
Three awn	*Aristida* spp.
Tobosa	*Hilaria mutica*
Tupelo	*Nyssa* spp.
Valley oak	*Quercus lobata*
Water hickory	*Carya aquatica*

Common name	Scientific name
Water oak	*Quercus nigra*
Water tupelo	*Nyssa aquatica*
Western hemlock	*Tsuga heterophylla*
Western juniper	*Juniperus occidentalis*
Western red cedar	*Thuja plicata*
Western white pine	*Pinus monticola*
Wheatgrass	*Agropyron* spp.
White oak	*Quercus alba*
Willow	*Salix* spp.
Willow oak	*Quercus phellos*
Winterfat	*Eurotia lanata*
Wiregrass	*Aristida stricta*
Yaupon	*Ilex vomitoria*
Yellow birch	*Betula alleghaniensis*
Yellow popular	*Liriodendron tulipifera*
Yellow starthistle	*Centaurea solstitialis*

APPENDIX B: FOREST AND RANGE ECOSYSTEMS

INTRODUCTION

Classification systems have been developed to describe the diversity of vegetation across the Nation's landscape. In this document, forest and range vegetation will be described using the Forest and Range Environmental System (FRES) (Garrison et al. 1977). The relationship between the Society of American Forester's forest types and FRES is presented in Eyre (1980). More detailed forest and range classifications have been developed for specific regions, e.g., for western forest ecosystems (Alexander 1985, Franklin and Dyrness 1973, Johnston 1987, Mauk and Henderson 1984, Pfister et al. 1977) and for eastern forests ecosystems (Braun 1964). FRES types were not defined for Alaska and Hawaii. Forest and rangelands in Alaska have been described by McNicholas (1983). Hawaiian ecosystems have been described by Stone and Scott (1987).

A brief description of the FRES ecosystems is given below. The description of each ecosystem is taken from Garrison et al. (1977), unless otherwise referenced. The broad geographic locations of the FRES ecosystems are mapped in figure 2, and defined in table 1 in Chapter 1. Some of the diverse resource outputs from these ecosystems have been presented in tables 2, 3, and 4 in Chapter 1. More detailed information about fauna found on the nation's forest and rangelands can be found in Flather and Hoekstra (in press) and on timber products from forest lands in Haynes (in press).

EASTERN FOREST ECOSYSTEMS

White-Red-Jack Pine and Spruce-Fir Ecosystems

These forest ecosystems occur in the northeastern part of the Northern region (numbers 10 and 11 in fig. 2). Valued primarily for their timber production, these ecosystems also provide habitat to a variety of wildlife including white-tailed deer, moose, great horned owl, spruce grouse, and ruffed grouse (DeGraaf and Rudis 1986, Eyre 1980). The white-red-jack pine ecosystem also provides habitat for the endangered eastern timber wolf, peregrine falcon, and Kirtland warbler. Insects are important in the nutrient cycling and energy flow of the spruce-fir ecosystem. The spruce budworm, the eastern spruce beetle, and the black-headed budworm feed on needle leaves, and at epidemic levels, may cause serious damage to the forest stand (Shelford 1963). Understory vegetation is predominately shrubs and forbs (Eyre 1980).

Maple-Beech-Birch and Aspen-Birch Ecosystems

These ecosystems commingle along the Canadian border of the Northern region (numbers 18 and 19 in fig. 2). Before European settlement, this area was covered with white-red-jack pine and spruce-fir ecosystems. Paper birch and aspen regenerate on sites disturbed by wildfire or human impact, and are usually succeeded by spruce-fir or pine types, depending upon the location (Eyre 1980). The understory vegetation is typically shrubs or forbs providing good habitat for ruffed grouse, white-tailed deer, and moose (DeGraaf and Rudis 1986), while the cleared areas converted to pasture provide forage for the dairy industry of this region.

Oak-Pine and Oak-Hickory Ecosystems

These ecosystems span the central part of eastern United States, occurring in both the Northern and Southern regions (numbers 14 and 15 in fig. 2). Oak-pine forests are characterized by a stand composition of 50% or more in hardwoods and 25-49% in southern pines, mainly shortleaf pine. Grass and forb production is low in oak-pine when tree density is high (Thill and Wolters 1979), but can exceed a half ton per acre when the overstory is reduced by thinning (Wolters et al. 1982). The oak-pine type provides habitat for game species such as white-tailed deer and wild turkey (DeGraaf and Rudis 1986). Six distinctive vegetation communities were defined in the oak-hickory type by Garrison et al. (1977). Under three of these types—the oak savanna, the mosaic of oak-hickory forest and bluestem prairie on the Ozark Plateau, and the Cross Timbers in Texas and Oklahoma—grasses and forbs contribute significantly to understory composition and production. Under proper management, forage production can exceed 2 tons per acre, providing valuable forage for beef operations (Crawford and Porter 1974). The oak-hickory ecosystem provides habitat for game species such as white-tailed deer and mourning dove (Evans and Kirkman 1981) and a number of endangered plants and animals, including the southern bald eagle, red wolf, and the red-cockaded woodpecker.

Loblolly-Shortleaf Pine Ecosystem

This forest ecosystem covers an extensive area in the northern part of the Southern region (number 13 in fig. 2). These forests are characterized by stands in which 50% or more of the stand is loblolly pine, shortleaf pine, or other southern yellow pines, singly or in combination. Because of the large geographic extent of this type, the remaining stand composition is filled with many different kinds of tree associates. The characteristic understory vegetation is a dense stand of hardwoods, shrubs, woody vines, and pine regeneration. Changes in stand

structure resulting from age and management impact the openness of the stand affecting forage production (Grelen 1978), species composition of birds (Hamilton and Yurkunas 1987, Whiting and Fleet 1987), and small mammal populations (Mullin and Williams 1987). Under an open canopy, pinehill bluestem contributes significantly to herbaceous production, and as the stand ages, longleaf uniola begins to dominate with a decline in herbaceous production (Halls and Schuster 1965). This type is prime habitat for white-tailed deer (Thill 1983), wild turkey, bobwhite, and mourning dove.

Longleaf-Slash Pine Ecosystem

This forest ecosystem rings the coastal edge of the Southern region (number 12 in fig. 2). Longleaf pine, slash pine, or both in a stand composition of 50% or more characterizes this ecosystem. Site and geographic location determine the remaining tree stand composition (Eyre 1980). Upland sites include flowering dogwood, other oaks, hickories, yaupon, persimmon, and hawthorn. Wetter sites may be associated with red maple, sweetgum, blackgum, water, and laurel oak. Under periodic flooding, associates will include baldcypress, pondcypress, blackgum, or water tupelo. Understory vegetation consists of grasses and shrubs. Understories in Louisiana, Mississippi, Alabama, and northwest Florida are dominated by bluestem grasses (Grelen 1978). Florida and Georgia sandhills and pine flatwoods have an understory dominated by wiregrass with other species including saw-palmetto (Grelen 1978). Because of the extensive understory of grass, this type is important for livestock grazing. A number of endangered plants and animals occur, including the red-cockaded woodpecker and the Florida panther. Bobwhite and wild turkey are important game birds. Intensive logging, land clearing with subsequent abandonment, fire suppression, and recently, clearcutting have converted many longleaf-slash communities to pure stands of loblolly or slash pine (Eyre 1980, Grelen 1978).

Oak-Gum-Cypress Ecosystem

This Southern region type is characteristic of river flood plains, the cypress savanna west and the mangrove swamps south of the Florida Everglades, and the eastern coast of Florida, Georgia, and the Carolinas (number 16 in fig. 2). Within the river flood plains, common tree associates are broad-leaved deciduous trees such as willow, maple, sycamore, cottonwood, and beech. The mangrove swamp provides habitat for white-tailed deer and many endangered species such as Florida manatee, brown pelican, bald eagle, hawksbill sea turtle, and Atlantic ridley sea turtle (Odum et al. 1982). The cypress savanna is dominated by needle-leaved deciduous trees and some broad-leaved evergreen or deciduous trees and shrubs. White-tailed deer commonly utilize these habitats, along with gray fox, gray squirrel, fox squirrel, and other small mammals. Wild turkey is an important game bird. The flooded areas provide habitat for ibises, cormorants, herons, egrets, and kingfishers. Endangered species include Bachman's warbler, Florida panther, and bald eagle. Much of this area has been converted to either cropland or pasture. In 1977, Garrison et al. (1977) estimated that only the wettest parts of this type remained in forest, about 10%.

Elm-Ash-Cottonwood Ecosystem

This riparian vegetation type forms narrow corridors on the lower terraces and flood plains of the Mississippi, Missouri, Platte, Kansas, Arkansas, and Ohio Rivers (number 17 in fig. 2). Low to tall broadleaved deciduous trees vary from open to dense stands. Common tree associates differ in the northern and southern extents. The cottonwood-willow stage is usually succeeded by birch, maple, and elm species in the north and sycamore, pecan, elm, sugarberry, or green ash species in the south (Eyre 1980). This type is utilized by waterfowl such as mallard and wood duck, and other birds such as American woodcock and mourning dove (Evans and Kirkman 1981).

WESTERN FOREST ECOSYSTEMS

Douglas-Fir Ecosystem

This forest ecosystem occurs in the Rocky Mountain, the Pacific North, and the California regions (number 20 in fig. 2). Douglas-fir in the coastal regions occurs with western hemlock and western redcedar, and is not usually classified as a climax species because it is moderately intolerant to the low-light intensities characteristic of these forests. Within the Rocky Mountains, Douglas fir tends to occur in pure stands (Mitchell 1983). Understory vegetation varies with the topographic, climatic, and edaphic conditions of the site and ranges from grass-dominated communities to sites densely vegetated with shrubs to sites with little understory vegetation (Mitchell 1983). Mature stands offer little browse or forage, however forest openings and early seral stages offer habitat for elk, deer, black bear, grizzly bear, blue and ruffed grouse, hawks, owls, and mammalian predators such as mountain lions and bobcats and in the western extent, the endangered American peregrine falcon. The Oregon-listed endangered spotted owl has influenced the management of Douglas-fir lands in the Pacific Coast region (Salwasser 1987, Simberloff 1987). Fire suppression has favored tree regeneration at the expense of shrubs, grasses, and rapid tree growth (Arno and Gruell 1986, Gruell 1983, Wright and Bailey 1982). Under proper management, timber harvesting followed by slash burning opens up the site for range vegetation production, benefiting both wildlife and livestock (Wright and Bailey 1982).

Ponderosa Pine Ecosystem

This forest ecosystem is also widely distributed in all western regions (number 21 in fig. 2). By definition, the ponderosa pine ecosystem contains 50% or more of one of these pines: ponderosa, Jeffrey, sugar, limber, Arizona ponderosa, Apache, or Chihuahua (Garrison et al. 1977). The remaining stand composition varies by geographic region. Historical records indicate that fire kept this ecosystem open and parklike with an excellent ground cover of grasses, sedges, and forbs or with an understory of shrubs (Wright and Bailey 1982). Black bear, mule deer, elk, and mountain lion inhabit this forest type (Short 1983). This ecosystem provides timber, recreation, critical summer forage for livestock operations based at lower elevations, and prime summer range for mule deer and elk.

Fir-Spruce, Hemlock-Sitka Spruce, Western White Pine, and Larch Ecosystems

These forest ecosystems occur in the Rocky Mountains along the northern boundary of the Pacific North and Northern Rocky regions (numbers 23, 24, 22, and 25 in fig. 2). Fir-spruce forests, which also occur further south in the Northern Rocky Mountain region, generally have a dense canopy with little understory vegetation providing little forage for wild or domestic herbivores. Shrubs or forbs constitute the understory under the hemlock-sitka spruce and the western white pine ecosystem and are also found under some fir-spruce types (Eyre 1980). Larch is a seral type, succeeding to grand fir or Douglas-fir (Eyre 1980). These ecosystems are interspersed with meadows and stream bottoms with broad-leaved woody species such as aspen and willows. This mosaic of ecosystems provides habitat for moose, elk, mule deer, and white-tailed deer (Clary 1983). Other mammals include wolverine, lynx, black bear, mountain lion, coyote and, in small numbers, the grizzly bear.

Lodgepole Pine Ecosystem

Widespread over the entire western region, this ecosystem is characterized by a composition of 50% or more of lodgepole pine (number 26 in fig. 2). Understory vegetation is a function of the climatic, topographic, and edaphic characteristics of the site, and the time since the last disturbance (Bartolome 1983). Logging and fire shift understory species composition toward grasses and forbs, reducing shrubs. The 25 million acres dominated by lodgepole pine provide a significant source of forage for wild and domestic animals (Bartolome 1983). The fauna is similar to the Douglas-fir and spruce-fir ecosystems.

Redwood Ecosystem

This forest ecosystem covers a small geographic extent in California and Oregon (number 27 in fig. 2). The dense overstory of redwood (20% or more) may be in association with Douglas-fir and grand fir. Fauna include elk, mountain lion, bobcat, and black bear.

Western Hardwoods

Occurring in the Pacific Coast and Rocky Mountain regions, these forests are characterized by a stand composition of 50% or more of coast live oak, canyon live oak, blue oak, valley oak, interior live oak, or aspen. Understory vegetation is primarily grasses (number 28 in fig. 2). Fauna in the California extent include mule deer, California quail, mountain quail, skunk, and the endangered San Joaquin kit fox. Fauna in the Oregon extent is similar to the California extent, with the addition of more northerly species such as the ruffed grouse. In the Rocky Mountain extent, fauna are similar to the surrounding ecosystems. The aspen ecosystem produces significant amounts of forage in addition to valuable wood fiber in the Rocky Mountain region (Betters 1983).

GRASSLAND AND SHRUBLAND ECOSYSTEMS

Sagebrush Ecosystem

This ecosystem occupies the vast plains and plateaus derived from lava flows, ancient lake beds, and broad basins of alluvium in the Rocky Mountain, and the Pacific Coast regions (number 29 in fig. 2). This broad ecosystem type comprises several different sagebrush communities dominated by either different sagebrush species or by sagebrush and grass species (Blaisdell et al. 1982; West 1983a, 1983b). In the early years of western settlement, this type was severely impacted through grazing, cultivation, and the later abandonment of marginal farms (Blaisdell et al. 1982). Disruption of the fire cycle in the sagebrush ecosystem has led to the annualization of this type (West 1983a, 1983b). Heavy grazing pressure reduced the occurrence of the native perennial grasses, allowing sagebrush to increase. Once established, annual exotic plants such as cheatgrass provide the fine-textured fuel that allows wildfires to spread from shrub to shrub in the dry season (Young et al. 1987). The technology exists to reverse the process of annualization on sites with sufficient annual precipitation, however cheatgrass has expanded its range to include sites in the more arid margins of the Great Basin (Young et al. 1987). The sagebrush ecosystem provides habitat for game species such as sage grouse, pronghorn, and mule deer (McArthur et al. 1978) and habitat for the endangered Utah prairie dog (Garrison et al. 1977). The invasion of cheatgrass has facilitated the successful introduction of the exotic game bird, chukar partridge, which uses cheatgrass as a staple item of its diet (Leopold et al. 1981). Most wild horse herds occupy this type.

Desert Shrub and Southwestern Shrubsteppe Ecosystems

These ecosystems are found in areas of the Rocky Mountain and Pacific Coast regions (numbers 30 and 33 in fig. 2) where precipitation is usually less than 10

inches a year, and the soils are poorly developed (Stoddart et al. 1975). Generally these types are referred to as cold-desert shrublands of the temperate latitudes and hot-desert shrublands of tropical and subtropical areas. The sparse vegetation is dominated by woody plants less than 7 feet in height. Shrub species in the cold desert include shadscale, saltbush, various rabbitbrushes, greasewood, and winterfat with associated grasses and few forb species. The exotic cheatgrass has adapted to produce seed in the brief period during spring when moisture is abundant. The cold-desert shrublands furnish winter grazing for thousands of sheep and cattle (Stoddart et al. 1975) and habitat for the wildlife species such as mule deer, pronghorn, coyote, and collared peccary (Short 1983). Wild horses and burros use this ecosystem as well as the sagebrush and annual grasslands ecosystems (McArthur et al. 1978, Verner and Boss 1980). The hot-desert shrublands of California, Arizona, New Mexico, and Texas are dominated by cresotebush, mesquite, blackbrush, bursage, tarbush, paloverde, and cactus. The dominant grass species of black grama, three-awns, and tobosa are associated with side-oats grama and curly mesquite. Desert mule deer, collared peccary, antelope, desert bighorn sheep, quail, dove, and rabbit are important game species (Martin 1975). The desert tortoise, endangered in California, Nevada, and Arizona, occurs in this ecosystem (Short 1983). Hot-desert shrublands are grazed yearlong by wild and domestic herbivores. This type represents the longest history (400 years) of grazing on this continent (Stoddart et al. 1975). The geographic region within which the ecosystems of southwestern shrubsteppe, desert shrub, desert grassland occur are drained by numerous rivers and streams. Riparian vegetation along these waterways has undergone severe manipulation from water developments, overgrazing, and invasion of exotics such as saltcedar (Swift 1984).

Shinnery Ecosystem

This ecosystem forms a narrow corridor on the sand hills and river dunes along the Canadian River in Texas (number 31 in fig. 2). This midgrass prairie is associated with open to dense stands of broad-leaved deciduous shrubs, primarily shin oak, and occasionally needle-leaved low trees and shrubs. Grass species include little bluestem and side-oats grama, with occasional sand bluestem. Fauna reflect the surrounding ecosystems of plains grasslands, pinyon-juniper, and southwestern shrubsteppe.

Texas Savanna Ecosystem

This high shrub savanna ecosystem varies from dense to open canopies of broad-leaved, deciduous and evergreen low trees and shrubs, and needle-leaved evergreen low trees and shrubs (number 32 in fig. 2). The understory component is short-grass and mid-grass species, including bluestems, three-awns, buffalo grass, gramas, curly mesquite, and tobosa. Mesquite is the dominant shrub, although other shrubs include acacia, live oak, juniper, and ceniza shrub. This ecosystem is noted for the abundance of white-tailed deer, wild turkey (Garrison et al. 1977), and collared peccary (Schmidt and Gilbert 1978). Fox squirrel, ringtail, raccoon, mourning dove, scaled quail, and bobwhite also inhabit this ecosystem.

Chaparral-Mountain Shrub Ecosystem

This ecosystem varies across the Pacific Coast and Rocky Mountain regions within which it occurs (number 34 in fig. 2). The California chaparral is characterized by little summer rainfall and comparatively heavy winter precipitation. Although this ecosystem's chief value is watershed protection, livestock do obtain some forage from the chaparral (Stoddart et al. 1975). Part of the critical habitat for the California condor, now found only in captivity, is within this type. Large portions of this ecosystem have been converted to annual grasslands. In the Rocky Mountain foothills, this type exists as open savannas or dense stands of scrub oak. Found in scattered areas in Utah, Arizona, New Mexico, and Colorado, the mountain brush type occurs as a discontinuous transition zone between coniferous forest and grassland or sagebrush ecosystems. This type is not dominated by a single shrub species but rather the shrubs of serviceberry, ceanothus, and snowberry form open stands under which grasses provide suitable forage for livestock (Stoddart et al. 1975).

Pinyon-Juniper Ecosystem

This type, often adjacent to sagebrush, occupies the eroded and rough dissections of western basins and mountains in all of the western regions (number 35 in fig. 2). Pinyon pine and juniper occur as dense to open woodland and savanna woodland. These tree species may grow to 30 feet tall, but commonly are under 15 feet. Understory vegetation appears to be related to climatic patterns where in the cold winter and dry summer regimes, cool season grasses are found; in dry winter climates, warm season grasses occur; and with moist cool winters, chapparal understories are associated with this type. Livestock grazing has been an important use in this type where forage production may be as much as 600 pounds per acre in open stands. Livestock grazing is usually low-intensity, season-long or year-long (Clary 1987). Although past heavy grazing and the increased tree overstory have reduced the forage production available within this type, prescribed fire can be used to reestablish understory species (Everett 1987). Fauna include mule deer, mountain lion, coyote, bobcat, jackrabbit, and numerous species of birds. Commercial products from the pinyon-juniper woodlands are in greater demand today than 10 years ago (Spang 1987). The multiple use management of this ecosystem includes fuelwood, pine nuts, forage, wildlife habitat,

watershed protection, recreational opportunities, esthetic values, wilderness, and energy and mining activities (Spang 1987, Wagstaff 1987).

Mountain Grassland Ecosystem

Dominated by fescue and wheatgrass bunchgrasses, these grasslands are open untimbered areas surrounded by ponderosa pine, Douglas-fir, or lodgepole pine ecosystems (number 36 in fig. 2). The encroachment of trees is slow because of several factors including strong competition for moisture from the bunchgrasses, low temperatures, and soil heaving (Paulsen 1975). Fauna reflect the surrounding ecosystems. Livestock began grazing these grasslands at higher elevations in Colorado, Wyoming, and Montana over 100 years ago, and by 1900 most were overgrazed. Current use is less than 25% of the former high levels (Paulsen 1975). These grasslands are still important summer ranges for cattle and wildlife, have significance as watersheds for water delivery downstream, and are important recreation areas. Although considered originally part of the mountain grasslands (Garrison et al. 1977), the Palouse prairie is described as an intermountain-bunchgrass type by Stoddart et al. (1975). Unlike the mountain grasslands, the Palouse is a grassland not subject to invasion by trees. As a reflection of the deep soil high in organic matter, much of the Palouse Prairie in Oregon, Washington, and Idaho was plowed for production of small grains (Garrison et al. 1977).

Mountain Meadow Ecosystem

Wet to intermittently wet open sites within the forested zones in western mountains characterize this ecosystem (number 37 in fig. 2). Grasses, sedges, and rushes dominate, and fauna reflect the surrounding ecosystems. This type serves as a source of water, highly productive forage for big game such as mule deer, and elk (Turner and Paulsen 1976), forage for livestock, and recreational activities.

Plains Grassland Ecosystem

The short warm-season grasses of blue grama and buffalo grass dominate this ecosystem found in the Rocky Mountain region (number 38 in fig. 2). These grasses coexist with a minor component of forbs, and shrubs such as juniper, sagebrush, silver buffaloberry, skunkbush sumac, rabbitbrush, and mesquite. Two environmental gradients determine species composition within this type. The temperature gradient increases from north to south and the moisture gradient increases from west to east (Stoddart et al. 1975). Pronghorn, mule deer, white-tailed deer, and white-tailed and black-tailed jackrabbit grazed this vegetation type, while prairie dogs and a variety of small rodents provide food for coyotes and raptors. The greater prairie chicken, and sharptailed grouse are important game species. Grasshoppers annually consume 21 to 23% of available range vegetation (Hewitt and Onsager 1983) and at epidemic levels, can present considerable damage to the forage base. The long-billed curlew was once widely distributed across this region, and its decline has been associated with decreasing short-grass prairie habitat (Kantrud 1982). Although the primary economic use of this ecosystem is livestock grazing, agriculture also has an impact. The conversion of native grassland to cropland, called sodbusting, reached high levels during the late 1970s when a poor livestock economy was coupled with a relatively good grain market (Heimlich 1985, Huszar and Young 1984). This extensive land conversion provided much of the incentive for conservation provisions in the Food Security Act of 1985 (Joyce and Skold 1988). Within the plains grasslands and the prairie ecosystems, major river systems are vegetated by riparian communities such as elm-ash-cottonwood or oak-hickory ecosystems. The relative lack of forest vegetation on the plains makes these riparian communities important to wildlife (Swift 1984). Channelizations of streams, and agricultural developments have significantly reduced the original area of these riparian ecosystems (Swift 1984).

Prairie Ecosystem

This ecosystem (number 39 in fig. 2) is known as the true prairie (Risser et al. 1981). Bluestem grasses dominate and woody vegetation is rare. Some forbs occur. Fauna is similar to the plains grasslands ecosystem. The northern extent of this type, known as the prairie pothole region, is an important breeding ground for migratory waterfowl. Shelterbelt plantings have increased the habitat for birds such as mourning doves. Because of the high soil fertility, much of this type has been converted to cropland. The eastern interface of this ecosystem with the eastern deciduous forests results in a mixing of grasses, shrubs, and some trees in this type. Fire and goats have been used to suppress shrub and tree invasion into the prairie (Wright and Bailey 1982).

Desert Grassland Ecosystem

Blue and black grama, galleta, tobosa, curly mesquite, and several threeawn species are the dominant grasses of this southwestern ecosystem (number 40 in fig. 2). Other grass species vary with the moisture regime of a site. Shrubs, such as creosotebush, burroweed, cactus, and mesquite, have been associated with this type, however, extensive shrub invasion of grasslands has become a widespread phenomenon over the past 100 years (Pieper et al. 1983). Five factors were suggested for the invasion: increased livestock grazing, climatic change, increased competition among plant species, rabbits and rodents, and fire control. Pronghorn, collared peccary, and mourning dove inhabit this ecosystem (Short 1983). Grasshoppers and harvester ants can cause

considerable damage to desert grassland vegetation (Pieper et al. 1983).

Wet Grassland Ecosystem

This diverse type occurs as the wet prairies and marshes along the eastern coast, the Florida Everglades and palmetto prairie, the tule marshes in central California, and the wet grasslands on the floodplains in the Intermountain plateaus (number 41 in fig. 2). Cordgrass, saltgrass, and a few forbs form the coastal grassland ecosystem. Scattered shrubs and low to medium tall trees form the overstory with an understory of wiregrass and saw-palmetto in the palmetto grassland, or sawgrass and three-awn in the Everglades. Tules, other bulrushes, and sedges dominate the landscape in the wet marshes in the intermountain floodplains. Fauna in wet grasslands are as diverse as the grasslands. The Central Valley of California and the coastal marshes of Texas and Louisiana are important habitat for seasonal migrations of waterfowl, including the endangered whooping crane. Klopatek et al. (1979) estimated that by 1974, tule marshes had lost 89% of their original area, the Everglades had been reduced 57%, and the palmetto prairie, 27%. Losses were primarily the result of land conversion to cropland.

Annual Grassland Ecosystem

Introduced annual grasses dominate the vegetation, although forbs and perennial bunchgrasses can also be found in this ecosystem which extends from California north into Oregon (number 42 in fig. 2). Fauna includes mule deer, California quail, and numerous small mammals. Mourning dove is also an important species here (Verner and Boss 1980). Much of this type at lower elevations has been converted to irrigated agricultural land. At higher elevations, use is mainly livestock grazing, some dry farming and, because of the proximity to large metropolitan areas in California, intensive recreational use (California Department of Forestry 1987).

Alpine Ecosystem

This type occurs above timberline in the Rocky Mountain and Pacific Mountain systems (number 43 in fig. 2). Grasses, grasslike species, and forbs predominate. The particular composition reflects the environment of the site which can vary dramatically depending on wind and water stress. Wind swept, highly erosive, dry slopes may have cushion plant communities, whereas depressions in the landscape may form a wet meadow. Lakes and ponds with endemic trout can be found within the type, although many lakes have been stocked with introduced species (Thilenius 1975). Year-round mammals include pika, pocket gopher, and yellow-bellied marmot. An important game bird is the ptarmigan. Mule deer, elk, and mountain sheep use the ecosystem for summer forage. Traditionally, large bands of domestic sheep used this ecosystem in summer. This practice has diminished in use, mainly because of the decline in the range sheep industry. Recreational use consists of hiking, hunting, and fishing during the summer, and skiing during the winter (Thilenius 1975).

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APPENDIX C: ENDANGERED (E) AND THREATENED (T) PLANTS AND THEIR DISTRIBUTION WITHIN THEUNITED STATES AND TERRITORIES.

Species				
Scientific name	Common name	Range	Status	Year listed
Agavaceae-Agave family:				
Agave arizonica	Arizona agave	AZ	E	1984
Aizoaceae-Ice plant family:				
Geocarpon minimum	None	AR, MO	T	1987
Alismataceae-Water-plantain family:				
Sagittaria fasciculata	Bunched arrowhead	NC, SC	E	1979
Amaranthaceae-Amaranth family:				
Achyranthes rotundata	None	HI	E	1986
Annonaceae-Custard-apple family:				
Asimina tetramera	Four-petal pawpaw	FL	E	1986
Deeringothamnus pulchellus	Beautiful pawpaw	FL	E	1986
Deeringothamnus rugelii	Rugel's pawpaw	FL	E	1986
Apiaceae-Parsley family:				
Eryngium constancei	Loch Lomond coyote-thistle	CA	E	1986
Eryngium cuneifolium	Snakeroot	FL	E	1987
Oxypolis canbyi	Canby's dropwort	DE, GA, MD, NC, SC	E	1986
Apocynaceae-Dogbane family:				
Cycladenia humilis var. jonesii	Jones cycladenia	AZ, UT	T	1986
Aquifoliaceae-Holly family:				
Ilex cookii	Cook's holly	Puerto Rico	E	1987
Asclepiadaceae-Milkweed family:				
Asclepias welshii	Welsh's milkweed	UT	T	1987
Aspleniaceae:				
Polystichum aleuticum	Aleutian shield-fern	AK	E	1988
Asteraceae-Aster family:				
Argyroxiphium sandwicense ssp. sandwicense	'Ahinahina (Muana Kea silversword)	HI	E	1986
Bidens cuneata	Cuneate bidens	HI	E	1984
Chrysopsis floridana (= Heterotheca floridana)	Florida golden aster	FL	E	1986
Cirsium vinaceum	Sacramento Mountains thistle	NM	T	1987
Dyssodia tephroleuca	Ashy dogweed	TX	E	1984
Echinacea tennesseensis	Tennessee purple coneflower	TN	E	1979
Enceliopsis nudicaulis var. corrugata	Ash Meadows sunray	NV	T	1985
Erigeron maguirei var. maguirei	Maguire daisy	UT	E	1985
Erigeron rhizomatus	Rhizome fleabane	NM	T	1985
Grindelia fraxinopratensis	Ash Meadows gumplant	CA, NV	T	1985
Hymenoxys acaulis var. glabra	Lakeside daisy	OH	T	1988
Hymenoxys texana	None	TX	E	1986
Liatris helleri	Heller's blazing star	NC	T	1987
Lipochaeta venosa	None	HI	E	1979
Pityopsis ruthii (= Heterotheca ruthii, = Chrysopsis ruthii)	Ruth's golden aster	TN	E	1985
Senecio franciscanus	San Francisco Peaks groundsel	AZ	T	1983
Solidago albopilosa	White-haired goldenrod	KY	T	1988
Solidago shortii	Short's goldenrod	KY	E	1985
Solidago spithamaea	Blue Ridge goldenrod	NC, TN	T	1985
Stephanomeria malheurensis	Malheur wire-lettuce	OR	E	1982
Townsendia aprica	Last Chance townsendia	UT	T	1985
Berberidaceae-Barberry family:				
Mahonia sonnei (= Berberis s.)	Truckee barberry	CA	E	1979
Betulaceae-Birch family:				
Betula uber	Virginia round leaf-birch	VA	E	1978
Bignoniaceae-Bignonia family:				
Crescentia portoricensis	Higuero de Sierra	Puerto Rico	E	1987

Species		Range	Status	Year listed
Scientific name	**Common name**			
Boraginaceae-Borage family:				
Amsinckia grandiflora	Large-flowered fiddleneck	CA	E	1985
Brassicaceae-Mustard family:				
Arabis mcdonaldiana	McDonald's rock-cress	CA	E	1978
Erysimum capitatum var. angustatum	Contra Costa wallflower	CA	E	1978
Glaucocarpum suffrutescens	Toad-flax cress	UT	E	1987
Lesquerella filiformis	Missouri bladderpod	MO	E	1987
Lesquerella pallida	White bladderpod	TX	E	1987
Thelypodium stenopetalum	Slender-petaled mustard	CA	E	1984
Warea carteri	Carter's mustard	FL	E	1987
Warea amplexifolia	Wide-leaf warea	FL	E	1987
Buxaceae-Boxwood family:				
Buxus vahlii	Vahl's boxwood	Puerto Rico	E	1985
Cactaceae-Cactus family:				
Ancistrocactus tobuschii (= Echinocactus t., Mammillaria t.)	Tobusch fishhook cactus	TX	E	1979
Cereus eriophorus var. fragrans	Fragrant prickly-apple	FL	E	1985
Cereus robinii	Key tree-cactus	FL	E	1984
Coryphantha minima (= C. nellieae, Escobaria n., Mammillaria n.)	Nellie cory cactus	TX	E	1979
Coryphantha ramillosa	Bunched cory cactus	TX	T	1979
Coryphantha robbinsorum (= Cochiseia r., Escobaria r.)	Cochise pincushion cactus	AZ	T	1986
Coryphantha sneedii var. leei (= Escobaria l., Mammillaria l.)	Lee pincushion cactus	NM	T	1979
Coryphantha sneedii var. sneedii (= Escobaria s., Mammillaria s.).	Sneed pincushion cactus	TX, NM	E	1979
Echinocactus horizonthalonius var. nicholii	Nichol's Turk's head cactus	AZ	E	1979
Echinocereus engelmannii var. purpureus	Purple-spined hedgehog cactus	UT	E	1979
Echinocereus fendleri var. kuenzleri (= E. kuenzleri, E. hempelii of authors, not Fobe)	Kuenzler hedgehog cactus	NM	E	1979
Echinocereus lloydii (= E. roetteri var. l.)	Lloyd's hedgehog cactus	TX	E	1979
Echinocereus reichenbachii var. albertii (= E. melanocentrus)	Black lace cactus	TX	E	1979
Echinocereus triglochidiatus var. arizonicus (= E. arizonicus)	Arizona hedgehog cactus	AZ	E	1979
Echinocereus triglochidiatus var. inermis (= E. coccineus var. i., E. phoeniceus var. i.)	Spineless hedgehog cactus	CO, UT	E	1979
Echinocereus viridiflorus var. davisii (= E. davisii)	Davis' green pitaya	TX	E	1979
Neolloydia mariposensis (= Echinocactus m., Echinomastus m.)	Lloyd's Mariposa cactus	TX	T	1979
Pediocactus bradyi (= Toumeya b.)	Brady pincushion cactus	AZ	E	1979
Pediocactus despainii	San Rafael cactus	UT	E	1987
Pediocactus knowltonii (= P. bradyi var. k. Toumeya k.)	Knowlton cactus	NM, CO	E	1979
Pediocactus peeblesianus var. peeblesianus (= Echinocactus p., Navajoa p., Toumeya p., Utahia p.)	Peebles Navaho cactus	AZ	E	1979
Pediocactus sileri (= Echinocactus s., Utahia s.)	Siler pincushion cactus	AZ, UT	E	1979
Sclerocactus glaucus (= Echinocactus g., E. subglaucus, E. whipplei var. g., Pediocactus g., S. franklinii, S. whipplei var. g.)	Uinta Basin hookless cactus	CO, UT	T	1979
Sclerocactus mesae verdae (= Coloradoa m., Echinocactus m., Pediocactus m.)	Mesa Verde cactus	CO, NM	T	1979
Sclerocactus wrightiae (= Pediocactus w.)	Wright fishhook cactus	UT	E	1979
Caryophyllaceae-Pink family:				
Arenaria cumberlandensis	Cumberland sandwort	TN, KY	E	1988
Paronychia chartacea (= Nyachia pulvinata)	Papery whitlow-wort	FL	T	1987
Schiedea adamantis	Diamond Head schiedea	HI	E	1984
Chenopodiacea-Goosefoot family:				
Nitrophila mohavensis	Amargosa niterwort	CA	E	1985
Cistaceae-Rockrose family:				
Hudsonia montana	Mountain golden heather	NC	T	1980
Convolvulaceae-Morning glory family:				
Bonamia grandiflora	Florida bonamia	FL	T	1987

Species				
Scientific name	Common name	Range	Status	Year listed
Crassulaceae-Stonecrop family:				
Dudleya traskiae	Santa Barbara Island liveforever	CA	E	1978
Cucurbitaceae-Gourd family:				
Tumamoca macdougalii	Tumamoc globe-berry	AZ	E	1986
Cupressaceae-Cypress family:				
Cupressus abramsiana	Santa Cruz cypress	CA	E	1987
Cyatheaceae-Tree ferm family:				
Cyathea dryopteroides	Elfin tree fern	Puerto Rico	E	1987
Cyperaceae-Sedge family:				
Carex specuicola	None	AZ	T	1985
Ericaceae-Heath family:				
Arctostaphylos pungens var. ravenii (= A. hookeri ssp. ravenii)	Presidio (= Raven's) manzanita	CA	E	1979
Rhododendron chapmanii	Chapman rhododendron	FL	E	1979
Euphorbiaceae-Spurge family:				
Euphorbia (= Chamaesyce) deltoidea ssp. deltoidea	Spurge	FL	E	1985
Euphorbia (= Chamaesyce) garberi	None	FL	T	1985
Euphorbia skottsbergii var. kalaeloana	Ewa Plains 'akoko	HI	E	1982
Fabaceae-Pea family:				
Amorpha crenulata	Crenulate lead-plant	FL	E	1985
Astragalus humillimus	Mancos milk-vetch	CO, NM	E	1985
Astragalus montii	Heliotrope milk-vetch	UT	T	1987
Astragalus perianus	Rydberg milk-vetch	UT	T	1978
Astragalus phoenix	Ash Meadows milk-vetch	NV	T	1985
Astragalus robbinsii var. jesupi	Jesup's milk-vetch	VT, NH	E	1987
Baptisia arachnifera	Hairy rattleweed	GA	E	1978
Galactia smallii	Small's milkpea	FL	E	1985
Hoffmannseggia tenella	Slender rush-pea	TX	E	1985
Lespedeza leptostachya	Prairie bush-clover	IA, IL, MN, WI	T	1987
Lotus dendroideus ssp. traskiae (= L. scoparius ssp. t.)	San Clemente Island broom	CA	E	1977
Lupinus aridorum	Scrub lupine	FL	E	1987
Mezoneuron kavaiense	Uhiuhi	HI	E	1986
Serianthes nelsonii	Hayun lagu (Guam) Tronkon guafi (Rota)	Guam Rota	E	1987
Trifolium stoloniferum	Running buffalo clover	WV, KY, IN	E	1987
Vicia menziesii	Hawaiian vetch	HI	E	1978
Flacourtiaceae-Flacourtia family:				
Banara vanderbiltii	Palo de Ramon	Puerto Rico	E	1987
Frankeniaceae-Frankenia family:				
Frankenia johnstonii	Johnston's frankenia	TX	E	1984
Gentianaceae-Gentian family:				
Centaurium namophilum	Spring-loving centaury	CA, NV	T	1985
Goodeniaceae-Goodenia family:				
Scaevola coriacea	Dwarf naupaka	HI	E	1986
Hydrophyllaceae-Waterleaf family:				
Phacelia argillacea	Clay phacelia	UT	E	1978
Phacelia formosula	North Park phacelia	CO	E	1982
Hypericaceae-St. Johns-Wort Family:				
Hypericum cumulicola	Highlands scrub hypericum	FL	E	1987
Isoetaceae-Quillwort family:				
Isoetes melanospora	Black-spored quillwort	GA, AL, SC	E	1988
I. tegetiformans	Mat-forming quillwort	GA, AL, SC	E	1988
Lamiaceae-Mint family:				
Acanthomintha obovata ssp. duttonii	San Mateo thornmint	CA	E	1985
Dicerandra cornutissima	Longspurred mint	FL	E	1985
Dicerandra frutescens	Scrub mint	FL	E	1985
Dicerandra immaculata	Lakela's mint	FL	E	1985
Haplostachys haplostachya var. angustifolia	None	HI	E	1979
Hedeoma apiculatum	McKittrick pennyroyal	TX, NM	T	1982
Hedeoma todsenii	Todsen's pennyroyal	NM	E	1981
Pogogyne abramsii	San Diego mesa mint	CA	E	1978

Species				
Scientific name	Common name	Range	Status	Year listed
Scutellaria montana	Large-flowered skullcap	GA, TN	E	1986
Stenogyne angustifolia var. angustifolia	None	HI	E	1979
Lauraceae-Laurel family:				
Lindera melissifolia	Pondberry	AL, AR, FL, GA, LA, MO, MS, NC, SC	E	1986
Liliaceae-Lily family:				
Erythronium propullans	Minnesota trout lily	MN	E	1986
Harperocallis flava	Harper's beauty	FL	E	1979
Trillium persistens	Persistent trillium	GA, SC	E	1978
Trillium reliquum	Relict trillium	AL, SC, GA	E	1988
Loasaceae-Loasa family:				
Mentzelia leucophylla	Ash Meadows blazing star	NV	T	1985
Lythraceae-Loosestrife family:				
Lysimachia asperulaefolia	Rough-leaved loosestrife	NC, SC	E	1987
Maalvaceae-Mallow family:				
Abutilon menziesii	Ko'oloa'ula	HI	E	1986
Callirhoe scabriuscula	Texas poppy-mallow	TX	E	1981
Hibiscadelphus distans	Kauai hau kuahiwi	HI	E	1986
Iliamna corei	Peter's Mountain mallow	VA	E	1986
Kokia cookei	Cooke's kokio	HI	E	1979
Kokia drynarioides	Koki'o (= hau hele'ula or Hawaii tree cotton)	HI	E	1984
Malacothamnus clementinus	San Clemente Island bush-mallow	CA	E	1977
Sidalcea pedata	Pedate checker-mallow	CA	E	1984
Meliaceae-Mahogany family:				
Trichilia triacantha	Baricao	Puerto Rico	E	1988
Nyctaginaceae-Four-o'clock family:				
Mirabilis macfarlanei	MacFarlane's four-o'clock	ID, OR	E	1979
Oleaceae-Olive family:				
Chionanthus pygmaeus	Pygmy fringe tree	FL	E	1987
Onagraceae-Evening-primrose family:				
Camissonia benitensis	San Benito evening-primrose	CA	T	1985
Oenothera avita ssp. eurekensis	Eureka Valley evening-primrose	CA	E	1978
Oenothera deltoides ssp. howellii	Antioch Dunes evening-primrose	CA	E	1978
Orchidaceae-Orchid family:				
Isotria medeoloides	Small whorled pogonia	CT, IL, MA, MD, ME, MI, MO, NC, NH, NJ, NY, PA, RI, SC, VA, VT	E	1982
Spiranthes parksii	Navasota ladies'-tresses	TX	E	1982
Papaveraceae-Poppy family:				
Arctomecon humilis	Dwarf bear-poppy	UT	E	1979
Piperaceae-Pepper family:				
Peperomia wheeleri	Wheeler's peperomia	Puerto Rico	E	1987
Poaceae-Grass family:				
Tuctoria mucronata (= Orcuttia m.)	Solano grass	CA	E	1978
Panicum carteri	Carter's panicgrass	HI	E	1983
Swallenia alexandrae	Eureka Dune grass	CA	E	1978
Zizania texana	Texas wild-rice	TX	E	1978
Polemoniacacea-Phlox family:				
Eriastrom densifolium	Santa Ana wooly-star	CA	E	1987
Polygalaceae-Milkwort family:				
Polygala smallii	Tiny polygala	FL	E	1985
Polygonaceae-Buckwheat family:				
Centrostegia leptoceras	Slender-horned spineflower	CA	E	1987
Eriogonum gypsophilum	Gypsum wild-buckwheat	NM	T	1981
Eriogonum ovalifolium var. williamsiae	Steamboat buckwheat	NV	E	1986
Eriogonum pelinophilum	Clay-loving wild-buckwheat	CO	E	1984
Polygonella basiramia (= Polygonella ciliata var. basiramia)	Wireweed	FL	E	1987

Species		Range	Status	Year listed
Scientific name	**Common name**			
Primulaceae-Primrose family:				
Primula maguirei	Maguire primrose	UT	T	1985
Ranunculaceae-Buttercup family:				
Aconitum noveboracense	Northern wild monkshood	IA, NY, OH, WI	T	1978
Clematis socialis	Alabama leather flower	AL	E	1986
Delphinium kinkiense	San Clemente Island larkspur	CA	E	1977
Rhamnaceae-Buckthorn family:				
Gouania hillebrandii	None	HI	E	1984
Rosaceae-Rose family:				
Cowania subintegra	Arizona cliffrose	AZ	E	1984
Ivesia eremica	Ash Meadows ivesia	NV	T	1985
Potentilla robbinsiana	Robbins' cinquefoil	NH, VT	E	1980
Prunus geniculata	Scrub plum	FL	E	1987
Rubiaceae-Coffee family:				
Gardenia brighamii	Na'u (Hawaiian gardenia)	HI	E	1985
Rutaceae-Citrus family:				
Zanthoxylum thomasianum	St. Thomas prickly-ash	Puerto Rico, Virgin Islands	E	1985
Santalaceae-Sandalwood family:				
Santalum freycinethianum var. lanaiense	Lanai sandalwood or 'iliahi	HI	E	1986
Sarraceniaceae-Pitcher plant family:				
Sarracenia oreophila	Green pitcher plant	AL, GA, TN	E	1980
Saxifragaceae-Saxifrage family:				
Ribes echinellum	Miccosukee gooseberry	FL, SC	T	1985
Scrophulariaceae-Snapdragon family:				
Amphianthus pusillus	Little amphianthus	GA, AL, SC	T	1988
Castilleja grisea	San Clemente Island Indian paintbrush	CA	E	1977
Cordylanthus maritimus ssp. maritimus	Salt marsh bird's-beak	CA	E	1978
Cordylanthus palmatus	Palmate-bracted bird's-beak	CA	E	1986
Pedicularis furbishiae	Furbish lousewort	ME	E	1978
Penstemon haydenii	Blowout penstemon	NE	E	1987
Solanaceae-Nightshade family:				
Goetzea elegans	Beautiful goetzea, matabuey	Puerto Rico	E	1985
Styracaceae-Styrax family:				
Styrax texana	Texas snowbells	TX	E	1984
Taxaceae-Yew family:				
Torreya taxifolia	Florida torreya	FL, GA	E	1984
Thymelaeaceae:				
Daphnopsis hellerana	None	Puerto Rico	E	1988
Verbenaceae - Verbena family:				
Cornutia obovata	Palo de Nigua	Puerto Rico	E	1988

Source: U.S. Department of Interior, Fish and Wildlife Service (1987, 1988), Endangered Species Technical Bulletin, Vol. 12, 13 (thru July 1988).

APPENDIX D: GLOSSARY

Sources for these definitions are listed at the end of the glossary.

Allelopathy.—Chemical inhibition of plants, through products of metabolism, upon each other.

Allotment.—An area designated for the use of a prescribed number and kind of livestock under one plan of management. May be federal or any combination of federal and private ownerships. May consist of several or only one pasture.

Allotment Management Plan (AMP).—The program of action designated to reach a given set of objectives for a given allotment on public lands. It is prepared and agreed to by the permittee(s) and appropriate agency and prescribes the livestock operations, range improvement practices, and maintenance.

Anadromous.—Migrating from the sea up a river to spawn; example, salmon.

Animal Unit (AU).—One mature cow of approximately 1,000 pounds and its calf, or equivalent. Conversion factors have been developed to equate other animal types to this animal unit.

Animal Unit Month (AUM).—Amount of forage required to sustain one animal unit (AU) for 1 month.

Aquifer.—A geologic formation capable of transmitting water through its pores at a rate sufficient for water supply purposes. Aquifers are usually saturated sands, gravel, fractures, caverns, or vesicular rock.

Arid.—A term applied to regions or climates where lack of sufficient moisture severely limits growth and production of vegetation. Limits of precipitation vary considerably according to temperature conditions, with an upper annual limit for cool regions of 10 inches or less and for tropical regions, 15 to 20 inches.

Assessment regions.—Regions used in this and other technical supporting documents and in the assessment document. See California, Northern, Northern Rocky, Pacific Coast, Pacific North, Rocky Mountain, Southern, and Southwest.

AUM.—See Animal Unit Month.

Biological control.—The control of parasites, plants, or other pests by the introduction, preservation, or facilitation of natural predators, parasites, or other enemies, by sterilization techniques, by the use of inhibitory hormones, or by other biological means.

Biotechnology.—Broadly defined, includes any technique that uses living organisms or processes to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses.

Boxed beef.—Cattle carcasses cut into small portions and boxed at the packing plant. Packing houses previously sold the retailer half or quarter carcasses of beef.

Breeding herd.—The animals retained for breeding purposes to provide for the perpetuation of the herd or band. Excludes animals being prepared for market.

Browse.—That part of leaf and twig growth of shrubs, woody vines, and trees available for animal consumption. Also the act of consuming browse.

California Region.—Assessment region encompassing the state of California. This is the National Forest System Region 5.

Carcass weight.—Weight of slaughtered animal after offal (inedible parts) are removed.

Carrying capacity.—The maximum stocking rate possible without inducing damage to vegetation or related resources. It may vary from year to year on the same area because of fluctuating forage production.

Cattle cycle.—A period of approximately 10 years in which the number of beef cattle is expanded for several consecutive years and then reduced for several years in response to perceived changes in profitability of beef production.

Channelization.—The process of excavating a waterway; straightening a streambed so that water flows more efficiently through an area.

Chaparral.—A shrub community composed of sclerophyllous species.

Climax.—The final or stable biotic community in a successional series which is self perpetuating and in dynamic equilibrium with the physical habitat, the assumed end point in secondary succession.

Cold deserts.—The Intermountain area or Great Basin Desert of North America, usually over 60% of its precipitation is in the form of snow.

Concentrate feed.—Grains or their products and other processed food materials that contain a high proportion of nutrients and are low in fiber and water.

Conservation compliance.—A provision of the 1985 Food Security Act that denies future commodity program benefits to producers who do not have specific conservation plans on highly erodible croplands now in production.

Conservation Reserve Program (CRP).—A provision of the 1985 Food Security Act that pays farmers to convert highly erodible cropland to permanent cover of grasses, shrubs, or trees, and to keep that land in permanent cover for 10 years. The land cannot be grazed by livestock or harvested for commercial purposes.

Constant dollars.—Dollars expressed in terms of purchasing power using a particular year as the standard of comparison, adjusted for inflation or deflation using a national index, such as the GNP index (Gross National Product).

Cool-season grasses.—A grass which generally makes the major portion of its growth during the late fall, winter, and early spring. Cool season plants generally exhibit the C-3 photosynthetic pathway, that is, the pentose phosphate pathway of carbon dioxide assimilation.

Coordinated Resource Management Planning (CRMP).—The process whereby various user groups are involved in discussion of alternative resource uses and collectively diagnose management problems, establish goals and objectives, and evaluate multiple use resource management.

Crop residue.—Plant material available for grazing on land from which a crop has been harvested.

Cropland.—Land under cultivation within the last 24 months including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, and land in soil improving crops, but excluding land cultivated in pasture.

CRP.—See Conservation Reserve Program.

Deeded nonirrigated grazing land.—Land owned as a part of the livestock enterprise that is not irrigated.

Defoliation.—The removal of plant leaves, i.e., by grazing or browsing, cutting, chemical defoliant, or natural phenomena such as hail, fire, or frost.

Demand.—The quantity of product willingly bought per unit of time at a specific price.

Desertification.—The process by which an area or region becomes more arid through loss of soil and vegetative cover.

Disposable personal income.—The amount of income available for spending.

Ecological status.—The present state of vegetation and soil protection of an ecological site in relation to the potential natural community for the site. Vegetation status is the expression of the relative degree to which the kinds, proportions, and amounts of plants in a community resemble that of the potential natural community. If classes are used, they should be described in ecological rather than utilization terms. Soil status is a measure of present vegetation and litter cover relative to the amount of cover needed on the site to prevent accelerated erosion.

Edible weight.—This weight measure excludes all bones, but includes the 1/4- to 1/2-inch of separable fat normally sold on retail cuts of meat such as beef, veal, pork, lamb, and mutton.

Endemic.—Local; native; indigenous.

Ephemeral.—Lasting a very short time; transitory.

Exotic.—An organism or species which is not native to where it is found.

Fed animals.—Livestock, usually cattle, in a feedlot.

Fed beef production.—Feeding of grain and other concentrate feedstuffs to produce slaughter cattle.

Feedlot.—A large plot of land where livestock are fed and fattened before slaughter.

Feral.—Escaped from cultivation or domestication and existing in the wild.

Forage.—Browse and herbage which is available and may provide food for grazing animals or be harvested for feeding.

Forb.—Any broad leafed herbaceous plant other than grasses, sedges, or rushes.

Forest land.—Land that is at least 10% stocked by forest trees of any size, including land that formerly had such a tree cover and that will be naturally or artificially regenerated. Forest land includes areas between heavily forested and nonforested lands that are at least 10% stocked with forest trees. Forest land includes pinyon juniper and chaparral areas in the West.

Grazed roughages.—Forage harvested by grazing or browsing forest, range, or pastureland. Roughages are plant materials containing a low proportion of nutrients per unit of weight and usually bulky and coarse, high in fiber, and low in total digestible nutrients.

Grazinglands.—A collective term that includes all lands having plants harvestable by grazing without reference to land tenure, other land uses, management, or treatment practices. Grazinglands include rangelands, transitory range, and forest lands which are suitable for grazing.

Grazing lease.—A document authorizing use of the public lands for the purpose of grazing livestock.

Habitat.—Place where an animals finds the required arrangement of food, cover, and water to meet its biological needs.

Hardwoods.—Dicotyledonous trees, usually broad-leaved and deciduous.

Harvested forages.—Forage mechanically harvested from pasturelands or haylands.

Heifer.—A cow that has not produced a calf and is under 3 years of age.

Herbaceous.—Vegetative growth with little or no woody component.

Herbage.—The above-ground biomass of herbaceous plants regardless of grazing preference or availability.

Herbicide.—Any chemical which is toxic to plants.

Herbivore.—Animals that subsist principally or entirely on plants or plant materials. Herbivores include domestic and wild grazers.

Human-related land use.—Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; roads; railroads; airports; beaches; rights-of-way; or other nonforest land not included in any other specified land use class.

Joint production.—Multiple outputs, such as wildlife and livestock, produced by combining multiple inputs, or management practices.

Multispecies grazing.—One species following another through the grazing area or two or more species grazing the area in combination.

National Forest System.—A branch of USDA Forest Service that manages and protects 191 million acres of land, including 32 million acres of wilderness.

National Grasslands.—Lands administered by the Forest Service but are excluded from the definition of rangelands in the Public Rangelands Improvement Act of 1978.

Nominal price.—Price including the real opportunity cost and inflation.

Non-use.—An authorization to refrain from grazing livestock without loss of preference for further consideration.

Northern Region.—Assessment region encompassing the states of Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, West Virginia, Pennsylvania, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine. This is National Forest System Region 9.

Northern Rocky Region.—Assessment region encompassing the states of Idaho, Montana, North Dakota, Wyoming, South Dakota, Nebraska, Kansas, Colorado, Utah, and Nevada. This is National Forest System Regions 1, 2, and 4.

Noxious.—Harmful or injurious to health or physical well-being; with the passage of the Noxious Weed Act, the term "noxious weed" has become a legal term referring only to those species designated by the Secretary of Agriculture as noxious weeds.

Oregon Range Evaluation Project (EVAL).—A test case in multiresource planning coordinated by numerous state and federal agencies.

Ornamental.—A plant cultivated for decorative purposes.

Pacific Coast Region.—Assessment region combining the Pacific North and California assessment regions.

Pacific North Region.—Assessment region encompassing the states of Oregon and Washington. This is National Forest System Region 6.

Palatability.—The relish with which a particular species or plant part is consumed by an animal.

Per capita.—Per person.

Perennial.—A woody or herbaceous plant living from year to year, not dying after one flowering.

Permit.—A document authorizing use of the public lands for the purpose of grazing livestock; grazing lease.

Pesticide.—A chemical agent such as herbicide, fungicide, insecticide, etc., used for control of specific organisms.

PNC.—See Potential Natural Community.

Potential Natural Community (PNC).—The biotic community that would become established if all successional sequences were completed without interferences by humans under the present environmental conditions.

Primary production.—The conversion of solar energy to chemical energy through the process of photosynthesis. It is represented by the total quantity of organic material produced with a given period by vegetation.

Private grazing land lease rate.—Price paid for the private rental arrangement between a rancher and a landowner.

Range betterment funds.—Portion of grazing fees paid that is prescribed to be used for range improvements.

Range condition.—A term relating to the present status of a unit of rangeland in terms of specific values or potentials. Specific definitions differ by agency.

Rangeland.—A type of land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs. Rangelands include natural grasslands, shrublands, savannas, most deserts, tundra, alpine plant communities, coastal marshes, wet meadows, riparian ecosystems, and plant communities dominated by introduced species.

Range improvement.—Any activity or program on or relating to rangelands which is designed to improve production of forage, change vegetation composition, control patterns of use, provide water, stabilize soil and water conditions, and provide habitat for livestock and wildlife. The term includes, but is not limited to, structure, treatment projects, and use of mechanical means to accomplish the desired result.

Range vegetation.—Plant species of grasses, grass-like plants, forbs, and shrubs. Range vegetation is most commonly associated with grassland and shrubland ecosystems, but is also found in many forest ecosystems.

Range vegetation management.—The management of range vegetation for multiple outputs which include herbaceous and shrub forage for both domestic and wild animals, water quality and quantity, air quality, open space, threatened and endangered plants and animals, genetic material, recreational use, plant diversity, community stability, and scenic quality. Management of range vegetation requires the application of knowledge, skills, and techniques based on ecological principles to maintain or reach established vegetative objectives while protecting fragile soils. The objectives for range vegetation management are defined in terms of species composition, condition, and the ability to provide a specified sustained level of use. Achievement of these vegetation objectives provides for an integrated mix of related resource uses and values.

Raptor.—Predatory bird.

Research.—A division of USDA Forest Service that develops scientific and technical knowledge to enhance the economic and environmental values of forest and rangelands.

Research Natural Area.—A land management category used by federal agencies to designate lands permanently reserved for research and educational purposes.

Resource value rating.—The value of vegetation present on an ecological site for a particular use or benefit; may be established for each plant community capable of being produced on an ecological site, including exotics or cultivated species.

Rest-rotation grazing system.—A grazing management scheme in which rest periods (no grazing) for individual grazing units are incorporated into a grazing rotation. Rest periods are generally the full growing season to permit seed production, establishment of seedlings, or restoration of plant vigor.

Retail weight.—Fixed percentage of carcass weight, specific to type of animal, and based on historical trends.

Riparian ecosystems.—The abiotic and biotic components found within the area defined by the banks and adjacent areas of water bodies, water courses, seeps, and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of contiguous flood plains and uplands.

Rocky Mountain Region.—Assessment region that combines Northern Rocky and Southwest Assessment regions.

Roundwood.—Logs, bolts, or other round sections cut from growing stock and nongrowing stock sources such as trees smaller than 5 inches d.b.h.; stumps, tops, and limbs of growing stock trees; rough and rotten trees; dead trees; and trees that grow on land other than timberland.

Ruminant.—Eventoed, hoofed mammal of the suborder *Ruminantia*, comprising cloven-hoofed, cud chewing quadrupeds. Includes cattle, deer, and camels.

Semiarid.—A term applied to regions or climates where moisture is normally greater than under arid conditions, but still definitely limits the production of vegetation. The upper limit of average annual precipitation in the cold, semiarid regions is as low as 15 inches, whereas in warm tropical regions it is as high as 45-50 inches.

Seral.—Refers to species or communities that are eventually replaced by other species or communities with a successional sequence.

Short-duration grazing system.—Grazing management whereby relatively short periods (days) of grazing and associated nongrazing are applied to range or pasture units. Periods of grazing and non-grazing are based upon plant growth characteristics.

Sodbuster.—A provision of the 1985 Food Security Act that causes farmers to become ineligible for price-support payments, farm-storage facility loans, crop insurance, and disaster payments if the farmer plows highly erodible land that is not currently cropped.

Softwoods.—Coniferous trees, usually evergreen, having needles or scale-like leaves.

Soil bank.—A government program established by the Agricultural Act of 1956; a large scale effort to bring about adjustments between supply and demand for agricultural products by taking farmland out of production.

Southern Region.—Assessment region encompassing the states of Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Tennessee, Kentucky, Virginia, North Carolina, South Carolina, Georgia, and Florida. This is National Forest System Region 8.

Southwest Region.—Assessment region encompassing the states of Arizona and New Mexico. This is National Forest System Region 3.

Special management pasture.—An area fenced and managed separately because of different management objectives as in riparian ecosystems.

State and Private Forestry.—A division of the USDA Forest Service that provides technical and financial assistance to states to help increase the productivity of nonindustrial private forest lands to meet projected resource demands.

Stocker cattle.—Cattle (calves and older animals) maintained primarily on pasture, range, or harvested forages to increase weight and maturity before being placed in a feedlot.

Succession.—The gradual process of progressive community change and replacement and modification of the physical environment, leading towards a stable potential natural community.

Supply.—The quantity of a product willingly offered for sale per unit of time at a specific price.

Swampbuster.—A provision of the 1985 Food Security Act that causes farmers to become ineligible for commodity program benefits if the producer drains wetlands.

Tallow.—The harder fat of sheep, cattle, etc., separated by melting from the fibrous and membranous matter naturally mixed with it, and used to make candles, soap, etc.

TAMM.—See Timber Assessment Market Model.

Timber Assessment Market Model (TAMM).—A simulation model that estimates roundwood harvest as a function of changes in timber prices and availability.

Timberland.—Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Areas qualifying as timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.

Timber Resource Inventory Model (TRIM).—A simulation model that projects changes in timber inventory, growth, and harvest.

Transitory range lands.—Lands managed principally for timber production but are suitable for forage production for grazing animals including wildlife and livestock during a period of time following thinning, harvest, or other timber management activity.

TRIM.—See Timber Resource Inventory Model.

Tules.—Bulrushes, large sedges, cattails, and such, collectively.

Understory.—Plants growing beneath the canopy of another plant. Usually refers to grasses, forbs, and low shrubs under a tree or brush canopy.

Urban land.—See Human-related land use.

Warm deserts.—The Mojave, Sonoran, and Chihuahuan deserts of North America; precipitation is in the form of rain.

Warm season grasses.—A grass which makes most or all its growth during the spring, summer, or fall, and is usually dormant in winter. Warm season plants usually exhibit the C-4 photosynthetic pathway, that is the dicarboxylic acid pathway of carbon dioxide assimilation.

Waterfowl.—A water bird, especially a swan, goose, or duck.

Weed.—A plant which is undesirable in light of planned land use or which is unwholesome to rangelands or range animals.

Xeric.—Having very little moisture, tolerating, or adapted to dry condition.

Sources

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